A Review of the
Marine Environmental Effects
of the
Sable Offshore Energy Project

prepared by

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Summary and Recommendations

This report provides a review of the SOEP Environmental Impact Statement and its supporting documentation, as they pertain to the marine environment. It was prepared for the Ecology Action Centre, in support of the Centre's intervention in the Joint Panel's public review of the SOEP proposal. This report is confined reviewing the SOEP Proponents' submissions and does not purport to be an Environmental Impact Statement nor should it be considered as a substitute for one.

The primary conclusion from this review is that the SOEP Proponents have failed to place before the Panel an adequate Environmental Impact Statement, containing a valid Environmental Impact Assessment. The deficiencies in their submissions are both many and severe. They include but are not limited to:

- No description of the proposed project has been provided with sufficient detail for its effects on the marine environment to be predicted.
- No adequate account of the marine environment has been generated, such that the effects on it of the project could be predicted with reasonable confidence.
- Much of the key information submitted was generated after the Environmental Impact Assessment was completed and thus was not used in that assessment.
- Comparative information on the environmental effects of offshore petroleum developments elsewhere was misrepresented, leading the Environmental Impact Assessment to be founded on an insufficient understanding of those effects.
- Components of the marine ecosystem that should have been included in the Environmental Impact Assessment were eliminated from consideration on inadequate grounds.
- Where gaps in current knowledge leave inevitable uncertainties, the Proponents erred on the side of judging potential impacts "insignificant", instead of "significant", as required by the Precautionary Principle.

The results of the Proponents' Assessment, in particular their list of residual impacts, should be rejected as inadequately supported by the information and analysis provided. Moreover, their Environmental Impact Statement does not provide a sufficient description of their intended project, nor one of the environment in the SOEP study area, for the Panel to use as a basis for a new, and valid, Environmental Impact Assessment. In consequence, it is not possible for the Panel or anyone else to determine, with reasonable certainty, the degree of harm to the marine environment that SOEP would cause. Approval of the SOEP proposal should, therefore, be deferred until such time as an adequate analysis of its environmental effects has been completed and has shown that they are acceptably small.

Rejection of a socially and economically beneficial, and environmentally benign, project on the grounds of inadequate environmental analysis alone would be a tragedy. There is, however, reason to suppose that, behind the uncertainties surrounding SOEP's environmental implications, lie real and undesirable impacts which, if they were adequately understood, might be deemed to out-weigh the various benefits of the project. They include but are not limited to:

- Discharged cuttings from drilling with oil-based muds would have a marked effect on the local benthic environment around the production platforms, certainly smothering

and destroying all life under the cuttings piles and possibly spreading toxic and persistent hydrocarbon contamination for some kilometres around each site.

- This hydrocarbon contamination would alter the community structure of the benthos throughout that area, affecting bottom-feeding fish in addition to its environmental impact.
- Relict deposits of oiled cuttings would probably remain at each site for many years. At the deeper sites, the cuttings might stay in discrete piles, a few tens of metres across. At the shallower sites, they are more likely to be spread as thin, but still persistent, layers across, or within, the natural sediments.
- Components of water-based drill muds, particularly bentonite and barite, might be released into the sea in sufficient concentrations to harm scallop production, and perhaps that of some other animals, within a few kilometres of the platforms, though only while drilling continued. This loss of production would be through reduced growth and perhaps decreased settlement of young, with deaths of adult scallops being confined to very small zones around the platforms.
- There is some possibility of a re-concentration of hydrocarbons and other contaminants in deep, sedimentary basins around the Bank, particularly parts of the Gully. The sources of these contaminants could include drill muds, produced water, flare residues and perhaps others. The effects of such contamination on the biota in that region, should it occur, remain unknown.
- The cutting of trenches for offshore pipelines, supplemented by natural scour and deposition around laid pipe, would disrupt a considerable seabed area. While the area affected would be a tiny fraction of the eastern Scotian Shelf, it could include a substantial proportion of some of the less-common habitat types in the region.
- Pipe laying could similarly disrupt habitat types used as commercial fishing grounds. Depending on the exact routes finally chosen for these pipelines, which have yet to be announced, the disrupted grounds could potentially include a high proportion of those available to local small-boat fishermen.
- Laying the natural gas liquids pipeline across the Strait of Canso would disturb sediments off Point Tupper that are known to be contaminated and may contain such highly-toxic materials as PCBs, dioxins and furans.
- SOEP's seismic surveys would have pronounced effects on both fish and marine mammals, not causing much death or injury but involving considerable behavioural disturbance, possibly leading to lost production. These effects can be expected to extend tens of kilometres from the survey area, such that animals in the Gully could be affected by surveys anywhere around Sable Island.
- These surveys would also cause a marked reduction in catch rates in commercial finfish fisheries for tens of kilometres around the survey areas, though those effects would be temporary and could potentially be mitigated.
- Pile driving during platform construction would have effects similar too, but less pronounced than, those of seismic surveys.
- There is the potential for a very serious risk to the world population of Ipswich sparrows, if the light emitted by SOEP production platforms close to Sable Island should cause the birds to miss their destination during an annual migration to the Island.
- Accidental condensate spills from SOEP operations and installations would involve some impact on the marine environment and, should a major spill occur, that impact could be very severe.

- A significant blowout near Sable Island, or a pipeline rupture either there or near Country Harbour, would be very damaging to shallow-water benthos, to sea- and shore-birds, possibly to marine mammals, maybe to sub-populations of planktonic organisms and perhaps to fishermen. The area affected by a major rupture near Country Harbour might reach as far as Cape Breton or the South Shore of Nova Scotia.
- A significant condensate tanker spill in Chedabucto Bay would be even more damaging. A “worst case” spill in that area, involving a million barrels of condensate, would be a major ecological disaster on a world scale.
- Such accidents are not likely but neither are they highly improbable. By the Proponents’ estimates, there is a 1-in-23 chance of a spill of over 10,000 barrels of condensate in a tanker accident, plus a 1-in-38 change of a similarly-sized spill from a pipeline rupture, over the 25 years of SOEP.
- Despite concern in some quarters, SOEP’s shipping and aircraft activities should not cause more than a minor increase to existing levels of similar disturbances in the Sable Island area. Thus, they would not cause significant impacts in the 1990s. If the existing proposal to establish a Marine Protected Area covering the Gully is brought to fruition, however, and if it introduces limitations on ship movements and shipping noise inside that area, SOEP’s shipping would have to be re-evaluated against different standards.

Some of the above issues are ignored in the SOEP Proponents’ various submissions and filings, notably the impacts of tanker accidents and the possible effect on Ipswich sparrows. Others are addressed but insufficiently, leaving considerable doubt as to the actual environmental consequences of the project, if it should proceed in its presently-proposed form.

Further study might show that some of the above issues are not of concern, while others might be avoided through mitigation or re-design of the project. Such studies should be done and their results should be incorporated into a new Environmental Impact Statement and Environmental Impact Analysis. Until that is done, however, these issues will remain as unresolved, unquantified and potentially-unacceptable possible impacts of SOEP.

The worst of the marine environmental problems associated with SOEP (barring major accidents or serious losses of Ipswich sparrows) would all result from the Proponents’ decision to discharge, at sea, drill cuttings coated with oil-based mud. Such discharge is not technically necessary and would no longer be permitted in most of the countries that have established experience with offshore drilling in cold-temperate environments, such as Norway, Denmark, Germany and the Netherlands. Even the United Kingdom does not permit the amount of oil-based mud discharge that the SOEP Proponents intend. Lacking the experience of the North Sea countries, Canadian regulatory standards still allow the practice. Until those standards can be reviewed in light of foreign experience, it should be prevented on a project-by-project basis. No proposal for offshore drilling in Canadian waters should be approved if it includes at-sea discharge of oiled cuttings.

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1. Introduction

In 1996 a group of Proponents submitted a proposal to the relevant regulatory agencies for the Sable Offshore Energy Project ("SOEP") – a project intended to develop six offshore natural gas fields in the vicinity of Sable Island, off Nova Scotia. The SOEP proposal has been placed before a Joint Public Review Panel ("the Panel"), charged with reviewing it with reference to several regulatory requirements. The Ecology Action Centre has Intervenor status before the Panel and has commissioned Gadus Associates to provide it with technical advice, pertaining to marine environmental and fisheries issues, in support of its intervention. This report has been prepared as the primary vehicle for that advice and in a form to be submitted to the Panel among the Ecology Action Centre's written evidence.

This report is a review of the Proponents' Environmental Impact Statement ("EIS") and supporting documentation. While it does attempt to set out and evaluate some of the impacts that SOEP would have on the marine environment, it does not purport to be and should not be treated as an independent EIS. As is explained below (Section 2), the Proponents' EIS is seriously deficient and does not provide an adequate basis for evaluating the environmental acceptability of their proposal. It is the proper role of an Intervenor to point out such deficiencies and to illustrate them but its is not an Intervenor's task to prepare a substitute EIS for a Proponent, nor will Intervenor funding support such work. No attempt is made here to do so and this report cannot be considered as such a substitute.

It is confined to reviewing the Proponents' documentation with reference to the impacts that SOEP would have seaward of the tideline and primarily to its marine environmental, as distinct from socio-economic, impacts. The lack of comment on other issues, particularly SOEP's impacts on the freshwater environment and the fish resources therein, should not be taken as any endorsement of those aspects of the EIS. Nor is this emphasis on marine issues intended as any form of comment on their relative importance compared to terrestrial ones. This is simply the scope set for Gadus Associates' review by the Ecology Action Centre.

The primary conclusion of this review is that the documentation filed before the Panel by the Proponents is seriously inadequate as a basis for the environmental component of the public review. This issue is dealt with in general terms first (Section 2), though many examples of deficiencies are noted elsewhere in this report. Thereafter, the impacts that SOEP would have on the marine environment are considered, in so far as the available information allows them to be predicted. While such considerations cannot substitute for a valid and adequate EIS, they do serve to show that there are potential significant impacts that the documentation filed by the Proponents does not address. For convenience, these discussions are primarily grouped by the phase of SOEP activity that would cause them: facilities construction (Section 3), drilling (Section 5) and production (Section 6). These phases are not chronological in the SOEP Proponents' plans, because of the proposed staggered development of different fields, but they do reflected different stages of the work at any one field. The shipping and aircraft activities that would accompany all three of the above phases are grouped into their own Section (Section 4), as are the assorted minor discharges from the offshore platforms that would occur at various points throughout the project (Section 7). Major accidents are then considered in Section 8, while both seismic surveys and the proposed natural gas liquids pipeline crossing of the Strait of Canso are given their own sections (Sections 9 and 10). This report concludes with a Section that considers the requirement for, and appropriate structure for overseeing, Environmental

Effects Monitoring (Section 11). The treatment of the material in each Section is adapted to the issues being addressed and will therefore seem inconsistent to readers.

Some aspects of SOEP's potential impacts on the marine environment are not addressed here for no better reason than the lack of time, under the Panel's schedule, to do them justice. They include all aspects of decommissioning the SOEP installations and most issues directly connected with the commercial performance of the fisheries, such as loss of access to fishing grounds and the possible tainting of fish resources by hydrocarbons. This lack of comment on such issues should not be considered as any form of statement of the acceptability of the Proponents' treatment of them. Indeed, in keeping with the intent to review SOEP's EIS rather than to prepare a substitute, the absence of discussion of any issue in this report should not be construed as an indication that it is not of concern.

This review does, however, attempt to go beyond the declared limits of the SOEP proposal to also consider the impacts of other offshore petroleum developments that would be encouraged by any success of SOEP. The SOEP Proponents and those of the associated Maritimes and Northeast Pipeline project have made clear their expectation that the socio-economic benefits of SOEP would most likely be followed by those of other similar projects or else by an expansion of the present 28-well SOEP[1]. I would concur completely with the Proponents' predictions in this regard. To the degree that those follow-on projects would be encouraged by SOEP, as the Proponents have suggested that they would, their impacts must be regarded as SOEP's impacts and they are so treated here.

[1] *SOEP Additional Written Evidence*, pp. 3-6; *SOEP Response to DFO Habitat Management Division Information Request* 4; M.E.J. Phelps, C.E.O., Westcoast Energy Inc., speech to Metropolitan Halifax Chamber of Commerce (printed in Halifax *Chronicle Herald* 10 February 1997).

2. Information Deficiencies

2.1 Incomplete and Delayed Filing of Information

Writing to the Panel before the hearing order was issued, the Proponents suggested that their DPA and Addenda would "allow the Panel to predict and assess with confidence the likely impacts of the SOEP"[2]. That was a most improbable contention: confident (and reasonably precise) predictions of the environmental effects of offshore petroleum development will not be possible until several more decades of research has been completed into the functioning of marine ecosystems and the impacts on them of the offshore industry[3]. Scientific understanding of the impacts of drilling and production in the North Sea is currently being revised, with the tidy conclusions reached a decade ago being discarded (see Section 4 below), and it is likely that there are further revolutions in our knowledge yet to come. Yet the North Sea has seen vastly more scientific study, offshore petroleum development and, particularly, study of offshore development than the Scotian Shelf. Confident predictions of the impacts of SOEP simply are not possible in the 1990s.

The relevant standard that the Proponents are expected to meet, when presenting their proposal for the Panel's review, is not however one of confident prediction but simply one of providing the Panel, and the public, with a reasonably reliable basis for judging whether or not the impacts of SOEP would be such that the project would have a net overall benefit and no specific, unacceptable effects[4]. Any standard based on reasonableness requires some judgement in its application and thus is open to debate and interpretation. However, in the writer's professional opinion, the SOEP submissions and filings fall far short of even this lesser standard. The SOEP EIS does not provide a sufficient basis for a proper assessment of the project's impacts, nor for adequate design of the mitigation measures needed to prevent the project causing unacceptable environmental harm.

This point has been made before by the present writer[5] but, in the interim, many of the deficiencies in the Proponents' EIS have been independently pointed out by other scientists, notably those in the Department of Fisheries and Oceans and in Environment Canada[6]. A number of commentators have suggested that parts of the EIS outside their own expertise have been performed adequately[7] but the Proponents' descriptions of the marine ecosystems, seabirds and marine fisheries in the SOEP study area have each been

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[2] Letter from R.H. Harper to the Secretariat of the Joint Review Panel, 6 December 1996.

[3] cf. Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8.

[4] This is intended as a general summary from a technical perspective. It does not purport to summarize the various legal or regulatory standards that may apply.

[5] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* 27p.

[6] Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* 40p. ; Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* 37p.

[7] e.g. Comments on marine biota in: Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* p. 8.

severely criticized by specialist reviewers[8]. Many specific points are noted elsewhere in this report and there is no virtue in repeating the other critiques here[9]. Suffice to say that the description of the receiving environment offered by the Proponents' EIS is inadequate and misleading. It does not form a suitable basis for an EIA, nor for the Panel's review. Nor indeed has the SOEP proposal itself yet been declared in enough detail and with enough certainty for its effects on the environment to be predicted, even were the latter understood completely[10].

Even the Proponents seem to have tacitly admitted the inadequacy of the information they have filed. Their EIS relies heavily on one prepared in 1983 for the then-*Venture Development Project* and actually goes as far as stating that it "updates [. . .] the 1983 EIS" and that "Additional details can be found in the 1983 EIS"[11]. Indeed, the Proponents have stated that "When the databases contained in the 1983 assessment and in the current SOEP documentation are taken together, they adequately represent the state of knowledge of the biological system"[12], suggesting that they are aware that their own filing alone does not provide an adequate representation of current knowledge. Yet, the Proponents have not filed the 1983 EIS as part of their submission[13] and it is not included among the materials before the Panel and Intervenors for review.

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[8] As indeed has the socio-economic information: Letter from A.R. McIver, Environment Canada, to the Secretariat of the Joint Review Panel, 4 February 1997, point #12; Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* pp. 34-37.

[9] One very specific (if not very important) point has been in dispute, however, and should be laid to rest here. In the fall, it was suggested that *SOEP Volume 3 – EIS* Table 4.6-1 had introduced a new and misleading use of the term "offshore" [Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 9.4]. The argument over this suggestion has since passed to and fro (*SOEP Responses to Scoping Process* Issue #18; *SOEP Response to Ecology Action Centre Information Request* 25), leading the Proponents to produce photocopies of table headings provided by DFO Statistics Branch which conform to the usage employed in the EIS. It is, therefore, clear that this non-standard choice of terms did not originate with the Proponents, contrary to the present writer's earlier suggestions. That usage remains non-standard, however, and in conflict with that in DFO's policies, regulations and management plans, along with that common in the fishing industry and even in the popular press. As such, Table 4.6-1 is likely to mislead readers of the EIS. Had the Proponents undertaken more than a superficial examination of the fisheries with which they propose to share the Scotian Shelf, they would have noticed the obvious discrepancy and could, perhaps, have found that table headings in computer print-outs generated by Statistics Branch are not a reliable source.

[10] Changes in the originally-submitted proposal have been introduced which Environment Canada, for one, has described as "not minor or trivial" (Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* p. 6). They include a very substantial increase in the quantity of drilling wastes expected to be discarded which was apparently not decided upon until after the EIA was completed (see Section 5.4 below). That increase, directly affecting what is generally supposed to be the primary impact of offshore gas developments, was alone enough to invalidate any EIA performed before it was decided upon.

[11] *SOEP Volume 3 – EIS* p. 4-122.

[12] *SOEP Responses to Scoping Process* Issue #17, emphasis added. The present writer does not accept the validity of the claim but it is the Proponents' position that is of relevance here.

[13] Despite encouragement to do so, the Proponents have not even specified any parts of the 1983 EIS that they wish to have considered alongside their more recent documents, claiming instead that all relevant material is repeated in the 1996 documents (*SOEP Response to Ecology Action Centre Information Request*

Furthermore, despite the Proponents' too-frequent inability to provide full responses to questions asked, the Panel's and the Intervenors' *Information Requests* have drawn out a great deal of information that would be essential to a proper review of the SOEP proposal – demonstrating, at least, that that information was lacking from the Proponents' original filings[14]. While this much information is now available, there is no guarantee that it is complete and its absence from the original EIS means that no overall picture of the project, incorporating enough detail for its evaluation, has been placed before the Panel or the public. Indeed, the late presentation of this information also raises the concern that it was not taken into account during the preparation of the SOEP EIA.

2.2 Comparative Analysis

Along with its information on the SOEP study area, the Proponents' EIS included what it termed "comparative analysis" – examination of the effects of similar projects elsewhere as a basis for evaluating the likely environmental effects of SOEP[15]. In practice, aside from passing mention of studies in the Beaufort Sea and of monitoring around the COPAN development[16], plus scattered citations of North Sea studies of seabed contamination, this "analysis" was confined to *SOEP Volume 3 – EIS* Section 6.7.6. Most of that was

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2). That position contradicts the one that they took earlier (*SOEP Responses to Scoping Process* Issue #17).

[14] To cite but the most extreme example: The present writer pointed out last fall that the maps of fishing grounds in the EIS were deficient (Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 9.3). The Proponents initially answered by suggesting (1) that the 1983 EIS provided a complementary picture to their own, (2) that their maps had been chosen for consistency with those of 1983, and (3) that they had used DFO data sets, which they suggested were preferable to the maps prepared by the present author in his former capacity as a DFO scientist [Kenchington, T.J., R.G. Halliday & G.D. Harrison (1994) Fishing grounds exploited in 1990 by groundfish longliners based in Canada's Scotia-Fundy Region. *NAFO Scientific Council Studies* 20: 65-84] and which had not been used in the EIS. What the Proponents did not note was that those maps had been specially commissioned by DFO, in response to a requirement set by the Haché Task Force of 1989, because the Department knew that its other sources of information on the grounds fished by the small-boat fleet were inadequate – including those information sources later used in the Proponents' EIS.

This rejection of an identified deficiency in their EIS was nevertheless followed by the Proponents' submission of extensive information on the fisheries of the SOEP study area and particularly on some of the grounds fished by the scallop, groundfish, swordfish and shrimp fleets (*SOEP Response to Panel Information Request* 2.15; *SOEP Response to Department of Fisheries and Oceans Habitat Management Division Information Request* 6). While that information is still confined to those fleet sectors that provide detailed logbooks to DFO, and to the years in which they have done so (and hence misses the grounds fished by others at other times), it does serve to show the sort of information that was available to the Proponents, is needed if their proposal is to be reviewed and yet was not provided in the SOEP EIS.

[15] *SOEP Volume 3 – EIS* pp. 2-11, Sections 6.3.1.1 & 6.7.6.

[16] Repeated attempts to obtain information on the COPAN experience to support the Panel's and the Intervenors' review of the SOEP proposal have been rebuffed by the Proponents [Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 3; *Ecology Action Centre Branch Information Request* 5]. They have merely insisted that they have used, and will continue to use, the experience from COPAN. They have not provided any of the information on this, the only other Atlantic Canadian offshore petroleum development project, which would have so greatly aided estimation of the effects of SOEP.

devoted to the long-discredited GURC, BLM and Buccaneer studies, carried out in the Gulf of Mexico in the 1970s[17]. Otherwise, less than half a page was devoted to a superficial summary of a ten-year-old review of North Sea experience. As has been noted before, that was insufficient[18]. Indeed, by ignoring the recent research that has led to a major shift in scientific understanding of the environmental effects of offshore drilling (see Section 4 below), the Proponents' original "comparative analysis" was seriously misleading. Their later claim that that it presented "a concise and current statement of known impacts of hydrocarbon exploration, development and production in the offshore environment"[19] was simply false.

In a subsequent filing, the Proponents provided a consultant's report, prepared on their behalf, in which the Paris Commission's "Agreed Facts" of 1985 (which emphasized the limited environmental impact of the offshore petroleum industry) were presented as though they were a current conclusion of specialists studying the effects of offshore drilling[20]. When it was pointed out, by the Ecology Action Centre, that research in the last decade had cast considerable doubt on those "Agreed Facts", leading many (if not all) specialists to reject them, the Proponents dismissed the current viewpoint as "an alternative opinion"[21]. They did not explain why it was an alternative that they had not placed before the Panel to aid its review.

In short, "comparative analysis" must form the primary basis for estimating the expected effects of SOEP – the rest of the EIS mainly serving to adapt international experience to the specific characteristics of the SOEP proposal and those of the eastern Scotian Shelf environment. Yet the "comparative analysis" offered by the Proponents, which presumably informed their EIA and shaped its conclusions, was seriously deficient, being dated and unbalanced. No list of residual impacts built on such a dubious foundation should be accepted.

2.3 EIA Methodology

If the information presented in support of the SOEP EIA is inadequate, the methods by which that assessment was performed were no less deficient. Components of the marine ecosystem that should have been of concern were not listed as ECCs[22], pathways that have

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[17] See, for example: Carney, R.S. (1987) A review of study designs for the detection of long-term environmental effects of offshore petroleum activities. *In:* D.F. Boesch & N.N. Rabalais (eds.) *Long-term Environmental Effects of Offshore Oil and Gas Development.* Elsevier Applied Science, London, pp. 651-696; Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8.

[18] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 3; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* item 6.7.6. (*SOEP Response to DFO Science Branch Information Request* did no respond to DFO's raising of this issue.)

[19] *SOEP – Responses to Scoping Process* Issue #14, emphasis added.

[20] CORDaH (1997) Review of the environmental effects of the deposition of oil based drill cuttings and release of oil based muds. *Report prepared for Mobil Oil Canada Properties Ltd.* 14p.

[21] *SOEP Response to Ecology Action Centre Information Request* 21.

[22] cf. Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Sections 8.2 & 10.3; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* items 4.2.3 & 5.3; Department of the Environment,

the potential to link the project to ECCs were not considered[23], such consideration as did occur utilized a grossly unrealistic model of the marine ecosystem[24], and hence the resulting list of VECs fell far short of being complete. Not least, Proponents were obliged to treat the Grassy Island National Historic Site, a federally designated protected area, as a VEC but did not[25]. Indeed, the steps leading from the potential ECCs to the final table of residual impacts are by no means transparent[26]. Many potential impacts seem never to have

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Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* p. 11. (Environment Canada's point, that the Proponents failed to include the primary food item of the threatened roseate tern is a particularly clear example of the deficient listing of ECCs. *SOEP Response to DFO Science Branch Information Request* 4.3 did no more than confirm the Intervenor's apparent suggestion that environmental components not deemed important and not considered, in advance of any formal analysis, "likely to be affected" were not listed as ECCs.)

[23] cf. Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Sections 10.7 & 10.11; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* items 5.3.1 & 6.4.5. (*SOEP Response to DFO Science Branch Information Request* offered no response to these points.)

[24] cf. Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* items 4.2.2.2 & 5.2.1. (*SOEP Response to DFO Science Branch Information Request* 4.2.2.2 provided information on bioaccumulation of pollutants but on the key ecosystem issue could do no more than point to one mention in the EIS of a prey organism – not to its proper use as an ECC.)

[25] Recent court decisions require that all federally designated protected areas be classed as VECs. The Proponents have stated that the did not accord that status to Grassy Island because it is some distance from their proposed pipeline routes and gas plant site and because it does not lie within the study areas for their assessments of either the proposed gas plant or the liquids pipeline [*SOEP Response to Ecology Action Centre Information Request* 13 (Socio-Economic)]. They evidently neglected to consider that its foreshore lies within their chosen study area for their offshore EIS and, most importantly, that it would be highly exposed to a spill from a major accident to a SOEP condensate tanker in Chedabucto Bay (see Section 8.2.5 below).

[26] cf. Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 10.5; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* item 5.3. (Neither *SOEP – Responses to Scoping Process* nor *SOEP Response to DFO Science Branch Information Request* offered any response to this point.)

The Ecology Action Centre subsequently suggested seven examples of potential ECCs (on six of which the Proponents had concluded there would be no residual impacts while the seventh was claimed to be subject to a single "localized and minor" residual impact) and requested the Proponents to explain the steps by which these potential-ECCs were dropped from the series of lists leading to that of residual impacts. It was hoped, thereby, to discover whether this lack of transparency actually concealed further deficiencies in the EIA. In their response (*SOEP Response to Ecology Action Centre Information Request* 6), the Proponents demonstrated that:

- They were unaware of a known concentration of haddock close to Sable Island.
- Their EIA had failed to consider a significant halibut resource in one of the principal receiving basins for drill wastes from SOEP operations.
- The only pathway linking their project to grey seals that the Proponents considered was underwater sound.
- Their EIA had also failed to consider Ipswich sparrows – the only known discrete taxon (a sub-species) that is wholly-confined to the vicinity of Sable Island during its breeding season and one formally deemed "vulnerable".

been evaluated and their absence from the final list of residual impacts represents nothing more than the inadequacy of the Proponents' EIA.

Their use of geographically-delimited VECs also merits some attention. They very properly include Sable Island and the Gully as VECs, on the grounds that they are unique ecological sites[27]. That is an appropriate decision. They also, and equally properly, list some environmental components within those geographically-defined VECs as VECs in their own right, subsequently examining effects that SOEP might have on them – cetaceans in the Gully and seals on Sable Island being the prime examples[28]. Yet other components that should have been listed as ECCs, such as Ipswich sparrows and, arguably, the halibut resource in the Gully, were not on the grounds, in part, that each area "as a whole was identified as a VEC"[29]. The error in such logic when applied to Ipswich sparrows caused the Proponents to miss an important impact pathway that could act on the birds when they are migrating to, rather than living on, Sable Island (see Section 6.4.2). The more general error in this use of VEC-designation is that few impacts would materially alter a geographic feature as large as the Gully, or even one as vulnerable as Sable Island, while many different impacts could each significantly affect one or more environmental components within such an area. Hiding a number of ECCs within a single geographically-delimited VEC prevents the proper examination of the full array of potential pathways leading to each such ECC.

Further, the Proponents' lack of recognition of an "unknown" impact, between their "significant" and "insignificant" ones, prevented them from dealing fairly with the many uncertainties inevitable in any EIA. Sadly, lacking an "unknown" rating, they seem to have chosen to report any uncertain impacts as "insignificant", when the conservative approach (in accord with the Precautionary Principle) would require their listing, under the Proponents' scheme, as "significant".

The Proponents have done little to answer these various criticisms. They have, however, suggested that the primary selection of VECs was made by following those in the 1983 EIS, adding the remarkable claim that "understanding of the marine communities in the SOEP project area has not changed substantially [. . .] in the intervening period"[30]. No response is really needed to such an admission.

Nor is that the full extent of the defects in the Proponents' assessment methods, there being a number of more specific ones. The inadequacy of using a single assessment to cover drilling at sites as environmentally-different as *Venture* and *Alma* has been pointed out by

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Although the other three chosen examples seem to have been dismissed for rather better reasons (albeit ones founded in the otherwise-inadequate EIA), this exercise showed that the unclear progression from potential-ECC to residual impact does conceal some inappropriate assessment decisions.

It may also be noted that the Proponents entertain the notion that they can identify and consider new VECs as their knowledge improves and the project proceeds (*SOEP Response to DFO Science Branch Information Request* 2.4). It is far from clear to the present writer what such *post hoc* listing of VECs would accomplish, once the Proponents had received approval to proceed with their project and became financially committed to its existing form.

[27] *SOEP Volume 3 – EIS*, Table 5.3-1.

[28] *SOEP Volume 3 – EIS*, pp. 6-10 to 6-13, Table 5.3-1.

[29] *SOEP Response to Ecology Action Centre Information Request* 6.

[30] *SOEP – Responses to Scoping Process* Issue #17.

DFO[31], as other over-simplifications of the EIA have also been[32]. The Proponents' frequent use of generic project plans, rather than of specific SOEP intentions, in its EIA has been noted[33]. The lack of consideration of population substructures in many ECCs has also been touched on[34], as has the weakness of the EIS's analysis of cumulative impacts[35]. Finally, the use of a description of the fisheries in the early 1990s as a model for assessing impacts in the first quarter of the twenty-first century has been criticised[36].

This last has at least received some response from the Proponents. To DFO, they have disputed a claimed reliance on data from 1994, insisting (correctly, if not very usefully) that they gave equal weight to each of the years 1993-95, and some to earlier periods[37]. Previously, they had stressed the latter point, claiming that information from the 1983 EIS gave a picture of the fisheries in a state complementary to that of 1993-95[38] – a point that neglected the overwhelming preponderance of the information on the latter period in the SOEP EIS's presentation. Most recently, the Ecology Action Centre has pointed out that one thing of which we can be certain is that the fisheries during the proposed "life" of SOEP will not closely resemble those of any former period and hence require a more sophisticated forecast of the form of fishing industry with which the Proponents would co-exist. In their response[39], the Proponents accepted that the fisheries will evolve, probably in ways that cannot be anticipated, and they pointed out that they had not claimed to have predicted the changes that would occur. They have not, however, withdrawn their EIA, which was based on an assumption that the effects on the fisheries of an offshore natural gas project, scheduled for 1999-2025, could be evaluated by examining the effects it would

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[31] Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* p. 3. *SOEP Response to DFO Science Branch Information Request* General Comments included a response to this point but hardly a refutation.

It is also notable that, as their preparations have continued, their consultants have seen the need for site-specific work [e.g. MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Section 4], though that has come too late to influence the results of their EIA.

[32] e.g. Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* items 4.2.3.5 [possibility of retention of condensate in gyre] & 5.1. (*SOEP Response to DFO Science Branch Information Request* did not offer a response to these points.)

[33] e.g. Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* p. 4. *SOEP Response to DFO Science Branch Information Request* General Comments responded only by suggesting that there would be "continuous improvement" in the project, which is tantamount to continuous invalidation of the EIA.

[34] e.g. Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Sections 8.3 & 10.4; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* item 4.6.2. (*SOEP – Responses to Scoping Process* & *SOEP Response to DFO Science Branch Information Request* include no relevant responses to this point.)

[35] *SOEP Response to Panel Information Request* 1.2.

[36] e.g. Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 9.2; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* items 4.2.3, 4.2.3.5, 4.6, 4.6.2.3 & 4.6.3.1; *SOEP Response to Ecology Action Centre Information Request* 9.

[37] *SOEP Response to DFO Science Branch Information Request* 4.6.

[38] *SOEP – Responses to Scoping Process* Issue #18.

[39] *SOEP Response to Ecology Action Centre Information Request* 9.

have had on the fisheries of 1993-95 (incompletely supplemented by those on the fisheries of the 1970s and early 1980s). Such an EIA is, at best, misleading and should be rejected.

2.4 Summary

Four conclusions may be drawn from these many deficiencies, two of them being straightforward: First, the Proponents' limited list of residual impacts of SOEP[40], which should be the key conclusion of their environmental analyses, is inadequately supported by their deficient EIS and EIA and thus should be rejected. Second, the information in their EIS is not sufficient for the development of an adequate EIA. Rather a return to the starting point, followed by a thorough re-working of the entire process, is required.

The third conclusion is less simple and more subjective. As has been pointed out previously[41], in their submission, the Proponents are not so much offering a proposal for the Panel's, and the public's, review as they are asking for broad and general approval to develop their own plans at a later stage. To provide such approval, the public would, I suggest, need a measure of trust in the Proponents' intention to protect the Canadian environment from undue harm. Yet the Proponents' determined defence of an inadequate EIS and their repeated refusal to fully and frankly answer information requests, even when those have no connection with commercial confidentiality and even when they come from government agencies or the Panel itself, do nothing to build that trust. The Proponents' apparent conclusion that the most favourable seasons for construction are (with limited exceptions) as environmentally suitable as any others[42] has not given grounds for confidence in their commitment to environmental concerns either. Nor has their pronouncement of the financially-optimal site for the gas plant as also being environmentally-optimal, a conclusion that needed heavy stress on the interests of aquaculture and disregard for those of both the wild-capture fisheries and natural marine habitats[43]. Thus, in this writer's opinion, the SOEP proposal demands close scrutiny, not the broad approval that the Proponents are asking for.

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[40] *SOEP Volume 3 – EIS* Table 7.7-1.

[41] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 2.
In a more recent example of this attitude, the Proponents have told the Government of the Province of Nova Scotia that they consider the submitted basic design parameters of their project to be primarily to provide "the basis for environmental assessment of the facilities and project operations" and that they can be changed after the assessment is complete – provided that "the predicted environmental effects are not materially exceeded" (*SOEP Response to Province of Nova Scotia Information Request* 1.3b). If accepted, that contention would entirely negate the purpose of environmental assessment and its public review, besides leaving the environment itself dependent on somebody's *ad hoc* estimation of whether the project alterations would lead to "material" change in its impacts.

[42] *SOEP Response to Panel Information Request* 2.55; *SOEP Response to Ecology Action Centre Information Request* 18.

[43] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, Section 5. Section 5.3.1 states that the locations of aquaculture sites, but not those of fishing grounds, were considered when screening Candidate Site Areas for the gas plant, and Appendix A5.1 confirms that "Fisheries" criteria were confined to aquacultural concerns. The high-preference rating given to the chosen gas-plant site from a "fisheries" perspective (Table 5.3-2) thus actually concerned aquaculture. Because of the adjacent lobster habitat, the chosen site was probably the worst possible location around Country Harbour, from a truly "fisheries" perspective, to place the plant and its pipeline approach. Of all of the areas considered, however, it had the lowest construction costs (Table 5.3-2).

Finally, from reading the extensive documentation that they have submitted to the Panel, it sometimes appears that the Proponents have approached the environmental review of SOEP as a hurdle to be jumped or avoided, with the public interest serving to raise the obstacle or move it into the Proponents' way. If that was indeed their view of the work, an opportunity to advance both their project and the surrounding environment will have been lost. A EIS should not be an effort directed to getting a pre-conceived project approved but rather a process leading towards a project design that is simultaneously economically- and environmentally-efficient[44]. Seeking to conceal aspects of a project or its effects on the environment prevents reasonable measures being taken to advance the development while simultaneously avoiding unacceptable impacts.

[44] To give but one example: A proper EIS would have explored the possibilities of arranging the discharge of OBM drill cuttings so that they fell to the seabed over a wide area, such that natural processes would disperse them and biodegradation of their OBM coating would be promoted. The Proponents have preferred to insist that, however they were discharged, their drill cuttings would be dispersed in the high-energy environment of the Scotian Shelf (*SOEP Response to Panel Information Request* 2.16), in the face of evidence from the southern North Sea [Stebbing, A.R.D., V. Dethlefsen, R.F. Addison, M. Carr, P.M. Chapman, W.P. Cofino, C. Heip, L. Karbe, M.N. Moore & A.D. Vethaak (1992) Overall summary and some conclusions from the Bremerhaven Workshop. *Marine Ecology Progress Series* 91: 323-329; Daan, R., H. van het Groenewoud, S.A. de Jong & M. Mulder (1992) Physico-chemical and biological features of a drilling site in the North Sea, 1 year after discharges of oil-contaminated drill cuttings. *Marine Ecology Progress Series* 91: 37-45; Daan, R. & M. Mulder (1992) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044] and even from the COPAN sites on the Scotian Shelf which Environment Canada has described as "biologically dead", with only slow improvement [*SOEP Response to Panel Information Request* 2.20; Letter from A.R. McIver, Environment Canada, to the Secretariat of the Joint Review Panel, 4 February 1997, point #1]. A real chance to reduce a serious environmental impact may have been lost in this way.

3. Construction Phase – Pipelines and Platforms

In so far as the marine environment is concerned, construction of the SOEP installations would involve two distinct groups of activities: assembling and placing the platforms at their designated sites and laying the various marine pipelines[45]. Each of these will involve a number of ancillary activities, of which only ship and aircraft operations (see Section 3) and seismic surveys (see Section 0) merit any special attention in this report. Otherwise, the impacts on the marine environment of the platform construction and pipelaying, including the impacts of the structures thus created, are addressed in this section.

3.1 Platforms

The SOEP proposal, as submitted, calls for six, seven or even eight offshore platforms to be installed off Sable Island. While no detailed engineering plans have yet been made public and indeed the Proponents have not categorically confined themselves to any specific proposal, they have stated an intent to use fixed steel jacket-type structures, supported on piles, for the *Thebaud* production and accommodation platforms, as well as for four satellite platforms. The final satellite platform, at *South Venture*, is proposed to be a tapered concrete caisson (also supported on piles), if indeed it is required at all[46]. Each of these structures would be constructed on land, transported by barge and anchored to the seabed by piles. The working component of each platform would then be lifted into place as a single unit. The *Thebaud* and *Venture* platforms are scheduled for initial construction before the end of 1997 and commissioning in 1999, with *North Triumph* to follow in the latter year. *South Venture* (if built), *Alma* and *Glenelg* would, however, not be emplaced until 2005 to 2007[47].

Since the construction would mostly occur ashore, the marine impacts would be rather simple. Aside from some very minor loss of debris to the seabed, there would only be the driving of piles, the direct occupation of some seabed area by the jackets' legs (plus the piles and various piping to the wells) and the addition of new submarine substrate, in the form of the jackets and associated structures – the so-called "reef effect". Of these, the amount of seabed occupied would be tiny in comparison to that used by the pipelines and, indeed, to that smothered by the drill cuttings discharged around the platforms (see Section 5). Thus, it will not be discussed separately here[48].

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[45] The separate task of laying a natural gas liquids pipeline across the Strait of Canso is examined in Section 9 of this report.

[46] *SOEP Volume 3 – EIS* pp. 3-3 to 3-4. The *South Venture* wells might be directionally drilled from the *Venture* platform. The eighth platform, should there be one, would be a wellhead platform at *Thebaud*, separate from the production platform.

[47] *SOEP Volume 3 – EIS* pp. 3-22 to 3-23.

[48] It was noted in the EIS as a possible pathway by which SOEP could impact the marine environment but does not appear in the Impact Assessment Matrix nor the table of residual impacts: *SOEP Volume 3 – EIS* p. 5-5, 5-11, Tables 6.3-1, 7.7-1.

3.1.1 Pile Driving

Driving piles into the seabed would have an obvious effect on a very small area but the real impact of the process is the noise that it would generate[49]. The Proponents' underwater sound consultant has stated that he knows of no measurements of the intensity of such noise, though he has cited some figures for the transient sounds of underwater pipe driving which, converted to standard units, amount to about 170 to 200 dB re 1 µPa at 1 m range from the source[50]. These intensities extend from about as loud as the noisiest ships up to a level 1,000 times more intense but they are still not as loud as the airguns used in seismic surveys (see Section 0).

It is likely that some fish and marine mammals will be startled by the commencement of pile driving at each platform site and, judging from the observed effects of seismic surveys (see Section 0), they may move some kilometres away, returning only days or weeks after the operation is completed. However, there is every reason to think that they will eventually return with little net loss of production. Thus, the impacts of the pile driving may be equated to a mild version of a seismic survey.

3.1.2 Reef Effect

It is often suggested that offshore platforms act as "artificial reefs", providing new substrates for benthic biota, attracting fish and perhaps even enhancing their production. The Proponents gave some attention to this issue in their EIS, returning to it at more length in a response to one of the Panel's *Information Requests* and submitting a consultant's report on relevant experience in the North Sea[51]. Their conclusion appears to be that biofouling on the platform structures will be something of a nuisance to maintenance and operation of the offshore facilities, while providing some small net increment to the marine ecosystem. Meanwhile, the structures themselves, aided by their biofouling communities, will serve to attract fish and perhaps even to provide a small net increase in their production. Some of the attracted fish will then be adversely affected by rig discharges. The Proponents seem to consider that all of these effects will be insignificant when considered on the scale of the adjacent Scotian Shelf ecosystem. If that is a fair summary of their position, I would agree with them on all points. The "reef effect", while possibly a positive benefit to the environment, is almost certainly too minor to be deemed significant.

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[49] The Proponents' EIS noted the generation of underwater sound as one pathway by which SOEP could impact the marine environment and did specifically mention the noise from pile driving: *SOEP Volume 3 – EIS* p. 5-5, 5-10, 6-12, 6-14, 7-13. In their Impact Assessment Matrix, however, they suggested that underwater noise produced during platform construction would affect only cetaceans and seals (*SOEP Volume 3 – EIS* Table 6.3-1), though in reality it would also affect finfish, as seismic survey noise has been shown to do (see Section 0). The effect in either case would almost certainly be as negligible as the Proponents suggest and thus their conclusion that there would be no residual impact (*SOEP Volume 3 – EIS* Table 7.7-1) seems justified.

[50] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* pp. 17-18. The conversions assume the conventional 20.log R spreading loss and an ambient noise level around 80 dB re 1 µPa.

[51] *SOEP Volume 3 – EIS* pp. 5-5, 5-10 to 5-11; *SOEP Response to Panel Information Request* 2.9; CORDaH (1997) Appraisal of the experience of marine fouling in the North Sea. *Report prepared for Mobil Oil Canada Properties Ltd.* No reference to habitat creation around the offshore platforms appears in the Proponents' Impact Assessment Matrix nor is it tabulated amongst the residual impacts (*SOEP Volume 3 – EIS* Tables 6.3-1, 7.7-1).

3.2 Pipelines

SOEP, as a natural gas project, would involve an extensive array of pipelines. Those in the marine environment would comprise a number of inter-field pipelines, linking the various satellite platforms to the production platform at *Thebaud*, and a main pipeline from *Thebaud* to the gas plant at Country Harbour. The proposed natural gas liquids pipeline to Point Tupper would also involve a short marine section, where it crossed the Strait of Canso, but that is discussed in Section 9 below. Accidental releases of gas and condensate, in the event of a pipeline rupture, are considered in Section 6. The remaining issues relating to laying of these marine pipelines and to their physical presence on the seabed thereafter are addressed in this Section.

The Proponents have outlined some possible environmental effects that could result from laying these pipelines but have claimed that, with mitigation, there would be no significant residual impacts. Unfortunately, they have presented neither a sufficient description of their proposed pipelaying activities nor an adequate description of the seabed environments that would be affected. Thus, it is not possible to assess the degree of impact that this part of the proposed construction would have. Furthermore, while they have dealt in some detail with the possible impacts of trenching the pipeline within Country Harbour, they have made no apparent attempt to assess the impacts of the trenches or the pipelines themselves in offshore areas. Thus, the Proponents' conclusion of no significant residual impact must be rejected as unproven. A significant risk of unacceptable impacts on the marine environment remains.

3.2.1 Deficiencies of Information

The offshore pipelines would comprise a major part of the infrastructure of SOEP and their construction would almost certainly involve the greater part of the marine environmental impacts of the construction phase of the project. Unfortunately, it is not possible to make even a tentative estimate of the severity of those impacts because the Proponents have refused to provide adequate information on either their specific proposals or the nature of the environment that would be impacted. These deficiencies were pointed out before the hearings were scheduled[52] and yet the Proponents have not resolved the problem.

3.2.1.1 Inadequate Definition of Pipeline Routes

The SOEP Proponents, some months ago, defined the over-land route of their proposed liquids pipeline in terms of a 1 km-wide corridor, which they had selected after consideration of a variety of constraints and which was presented to the public on 1:100,000 scale maps[53]. The route of the associated Maritimes and Northeast Pipeline has been similarly presented and, at the time of writing, is being reduced to a 25 m-wide corridor through detailed surveys. Even the route of the nearshore end (inside Country Harbour Head) of the pipeline from *Thebaud* has been defined in terms of a 500 m-wide corridor[54]. No such detailed routes for the offshore pipelines have yet been announced, however – despite their having been called for by the 1983 review panel[55]. Last fall, the

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[52] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 7.
[53] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Appendix A, Constraint Maps #1 to #4.
[54] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, Fig. 5.5-1.
[55] *SOEP Volume 3 – EIS*, p. 1-19.

Panel and Intervenors were offered only a vague, 25 km wide, corridor from *Thebaud* to the mainland, plus similarly-imprecise indications of likely routes for the inter-field pipelines[56]. The Proponents later offered the Panel a map which, they claimed, showed the "routes and depths being considered for the inter-field pipelines"[57], though in reality it presented only stylized representations of three possible routes from *Venture* to *Thebaud*, while also showing one such from *Thebaud* to Country Harbour – all on a scale of about 1:1,000,000[58]. In this same response, the Proponents' further stated that, at the time of its preparation, three routes for the main pipeline from *Thebaud* were still under consideration.

When this deficiency in the information submitted was pointed out in the fall[59], it was also noted that the Proponents had stated that they had undertaken a survey of their proposed offshore pipeline route from *Thebaud*, which they had estimated was 208 km in length[60]. It was suggested that the Proponents should make both the survey results and their chosen route public. In their response to the Intervenors' deficiency statements[61], the Proponents blithely ignored this issue of offshore pipeline routing, offering no acknowledgement of the comment at all. In consequence, the Ecology Action Centre raised it again among its requests for information, receiving in reply only a reference back to the Proponents' inadequate information provided as *SOEP Response to Panel Information Request* 2.35[62]. At the same time, the Ecology Action Centre also asked for a date by which the Proponents expected to have determined a final pipeline route, which generated the response that the Proponent did not expect to determine a final pipeline route until it finalized its pipeline design, sometime between the second quarter of 1997 and early 1998[63].

In the absence of a specific pipeline route, it might be possible to set boundaries to the variety of environments that the pipeline could cross, if the Proponents were able to specify constraint criteria under which their route selection would take place – perhaps making possible some generic environmental assessment of potential pipeline routes. However, even a request for the criteria by which the routes were being selected produced nothing more than another reference to *SOEP Response to Panel Information Request* 2.35[64], where the only relevant statement appears to be:

> Evaluation to select a preferred route will be based on economics, assessment of geotechnical uncertainties, environmental impacts and other factors such as optimum platform approaches.

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[56] *SOEP Volume 3 – EIS*, Fig. 1.3-1.

[57] *SOEP Response to Panel Information Request* 2.35.

[58] While this map was too crudely drawn to be certain, it appears that some of the proposed routes do not even lie entirely within the corridor areas declared in the Proponents' EIS.

[59] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 7.

[60] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, p. 3.3. It is not clear how the Proponents could have had such a precise figure for the length of a pipeline when they submitted *Addendum 2* if they were still considering three different pipeline routes when they later prepared *SOEP Response to Panel Information Request* 2.35.

[61] *SOEP Responses to Scoping Process*.

[62] *SOEP Response to Ecology Action Centre Information Request* 7.

[63] *SOEP Response to Panel Information Request* 2.34; *SOEP Response to Ecology Action Centre Information Request* 7.

[64] *SOEP Response to Ecology Action Centre Information Request* 7d.

That is no doubt an accurate summary but it fell very far short of being sufficient for determining the types of seabed that should be considered in an assessment.

In short, the Proponents are asking the Panel to review a number of offshore pipeline proposals without committing themselves to the routes that those pipelines would take and without even setting any constraints on where they might run, save for some wide corridors. Unless it is supposed, in the face of all reason and all knowledge of benthic ecology, that laying a marine pipeline has the same environmental effects regardless of the area on the eastern Scotian Shelf in which it is laid, it is impossible to assess the significance of those effects without details of the route to be followed. Without a specific route proposal from the Proponents, there is nothing to assess.

3.2.1.2 Absence of Factual Information on Seabed Habitats

If the Proponents' submissions on their proposed pipelines are insufficient as a basis for environmental assessment, the information they have filed on the seabed environment over which they wish to lay those pipelines is essentially non-existent. The original EIS offered five pages of generalities about the benthic ecosystem, most of it apparently drawn from the 1983 EIS with updating largely confined to comments on resource species, and a single small-scale map that is unacceptably imprecise and, in places, simply wrong[65]. This information deficiency was also pointed out in the fall[66] which, while it was not overtly acknowledged by the Proponents, did provoke some response[67] which is discussed below (see Section 3.2.1.3). Meanwhile, the Panel pointed out that the SOEP EIS was heavily reliant on a 13 year-old document, the 1983 EIS, and requested that the information be updated. In response, the Proponents simply insisted that all new knowledge obtained in the meanwhile had been incorporated into their EIS[68] – a contention that was misleading both with regard to specific information on the benthic biota of the SOEP study area but even more so with regard to knowledge of the functioning of northwest Atlantic benthic ecosystems. The standard being applied was, in any case, inappropriate. It would not be sufficient for the Proponents to assemble all of the available scientific information on ecosystems in their study area, even had they done so. What is required for an EIS is to assemble sufficient information for a reasoned judgement of the environmental effects of the proposed project, with original fieldwork being undertaken if necessary to achieve that standard. In the case of a pipeline, this will always require some new work, in the form of site-specific habitat surveys along the routes under consideration[69] – as is being done, however imperfectly in mid-winter, in the case of the Maritimes and Northeast Pipeline.

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[65] *SOEP Volume 3 – EIS*, pp. 4-128 to 4-133, Fig. 4.2-1. Dr. M. Chadwick, among others, has pointed out the most obvious error in the map: the incomplete presentation of surfclam beds is complemented with a "bed" shown in one of the few places on Banquereau where they do not occur (DFO Science Branch's *Information Request* Item 4.2.3.4 – not one of the points to which the Proponents chose to respond in *SOEP Response to Fisheries and Oceans Science Branch Information Requests*). The rest of the map is simply less conspicuously in error.

[66] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 7.

[67] *SOEP Responses to Scoping Process*, Issue #16.

[68] *SOEP Response to Panel Information Request* 1.1.

[69] Site specific habitat surveys are just as necessary at the offshore platform sites, as Dr. D.C. Gordon noted in DFO Science Branch's *Information Request* (Item 4.2.3.4). That was not one of the points to which the Proponents chose to respond (*SOEP Response to Fisheries and Oceans Science Branch Information Requests*).

Nor is the requirement simply for information on the habitats but also for that on existing human uses of those habitats – which in the present case means information on the distribution of fishing grounds. Equivalent information on use of land areas along a pipeline route is often available in the form of published maps but, in the sea, new compilations of existing data and the collection of new data are usually required. When this point was raised in the fall, the Proponents only reply was that they would route their pipeline according to "bottom conditions and ecological concerns"[70] – which gave no assurance of consideration for fishing grounds and anyway presupposed that the Proponents would have access to the site-specific information on potential routes that they had not gathered[71].

Considering these issues, the Ecology Action Centre then asked the Proponents, in an Information Request, to place before the Panel and the Intervenors all site-specific information that they held relating to benthic habitats along the pipeline corridors (and at the proposed platform sites), along with its plans to obtain more such information. In response[72], the Proponents noted that the results of geotechnical surveys (which are not habitat information) would be provided to the Panel (not the Intervenors), at their request, around the end of March or approximately one week before the formal hearings are scheduled to commence. They further noted that additional geotechnical and geophysical surveys would be undertaken in the summer of 1997[73] but made no mention of intending to survey benthic habitats. It therefore appears that the Proponents neither have any information on the specific offshore habitats through which they propose to lay their pipelines nor do they have any intention of gathering such information.

For the outer basin of Country Harbour, through which the pipeline from *Thebaud* would pass, the Proponents have provided more detailed habitat information[74]. While the site-specific sampling undertaken there was minimal (some ROV video recording, sidescan sonar work and three sediment/benthos samples taken with a light-weight grab), the Proponents did have the benefit of data previously collected by the Guysborough County Mapping Project. When combined with knowledge of inshore habitats elsewhere on the Atlantic coast of Nova Scotia, this arguably provides a sufficient basis for environmental assessment[75]. In doing so, it well illustrates the sort of information needed for the rest of the marine pipeline routes.

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[70] Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 7.1.1; *SOEP Responses to Scoping Process* Issue #20.

[71] Since that exchange, the Proponents have produced some detailed information on the distribution of fishing grounds, though only for certain sectors of the fishing industry and only for areas around their proposed platform sites, not along their intended pipeline routes: *SOEP Response to Panel Information Request* 2.15; *SOEP Response to DFO Habitat Management Division Information Request* 6

[72] *SOEP Response to Ecology Action Centre Information Request* 7e-g.

[73] *SOEP Response to Ecology Action Centre Information Request* 7.

[74] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, pp. 4-4 to 4-7 & 4-12 to 4-13, Figs. 4.2-1 & 4.3-1; *SOEP Response to Panel Information Requests* 2.32, 4.7 & 4.8. Further sediment sampling is planned, with regard to the possibility of existing mineral contamination (*SOEP Response to Panel Information Request* 4.13a).

[75] Alongside the information provided for the offshore pipeline route, the Proponents' submissions concerning the habitats in Country Harbour appear rich indeed. By more normal standards, they are still inadequate. The mapped information only shows fishing grounds for lobsters, scallops and sea urchins. Since lobsters are migratory animals and the season is restricted, by regulation, to one short period of their annual cycles, such a map does not even present an adequate summary of the distribution of habitats for

3.2.1.3 Importance of Scale of Spatial Heterogeneity

The level of spatial detail of habitat information required offshore may not be quite as high as that needed for the part of the pipeline within Country Harbour. In close proximity to Nova Scotia's dissected coastline, wave climates can vary markedly over scales of metres, or less, and those wave climates are important determinants of shallow sublittoral habitats[76]. Away from the coast, such marked spatial variations would not be expected over distances of less then ten or a hundred metres. Indeed, not many years ago, most marine scientists would have doubted that they occurred over distances of less than a few kilometres. Such an assumed lack of pronounced local heterogeneity in offshore seabed habitats is still an implicit foundation of the design of most fisheries surveys[77] and may underlie the Proponents' decision not to undertake site-specific habitat surveys along its pipeline routes.

That assumption is, however, wrong. Nova Scotian fixed-gear fishermen have long known that the seabed, in some offshore areas, is markedly variable over distances of 10 to 100 m and that achieving an adequate catch rate requires setting their gear on the right type of "bottom"[78]. More recently, as appropriate instrumentation has become available, scientists have confirmed the fishermen's practical knowledge[79]. Indeed, within part of the SOEP study area, it has been possible to quantify the spatial scale of variability in one habitat factor – variogram analysis of data from recent acoustic surveys of Banquereau, using ROXANN equipment, have shown an average habitat patch diameter of about 200 m[80]. As

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these three resource species, let alone for the other components of the local marine ecosystem. The Proponents' ROV observations are no substitute for an assessment by a competent biologist, while three grab samples (taken with an inappropriate grab, which required multiple drops to gather each sample) are grossly insufficient as a basis for describing a benthic community. This point was also made last fall [Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 7.2] but was not acknowledged by the Proponents in their *SOEP Responses to Scoping Process*.

[76] cf. Hiscock, K. (1983) Water movement. *In:* R. Earll & D.G. Erwin (eds.) *Sublittoral Ecology: The ecology of the shallow sublittoral benthos.* Clarendon Press, Oxford: 58-96.

[77] Including, for example, the Scotian Shelf groundfish surveys cited in the Proponents' EIS (*SOEP Volume 3 – EIS*, pp. 4-143 to 4-144, Fig. 4.2-5).

[78] Kenchington, T.J. & R.G. Halliday (1994) A survey of fishing practices in the Scotia-Fundy groundfish longline fisheries. *Canadian Manuscript Report of Fisheries and Aquatic Sciences* 2225: 642 p.

[79] See, for example: Lough, R.G., P.C. Valentine, D.C. Potter, P.J. Auditore, G.R. Bolz, J.D. Neilson & R.I. Perry (1989) Ecology and distribution of juvenile cod and haddock in relation to sediment type and bottom currents on eastern Georges Bank. *Marine Ecology Progress Series* 56: 1-12; Auster, P.J., R.J. Malatesta, S.C. LaRosa, R.A. Cooper & L.L. Stewart (1991) Microhabitat utilization by the megafaunal assemblage at a low relief outer continental shelf site – Middle Atlantic Bight, USA. *Journal of Northwest Atlantic Fisheries Science* 11: 59-69; Valentine, P.C. & R.G. Lough (1991) The sea floor environment and the fishery of eastern Georges Bank: The influence of geologic and oceanographic environmental factors on the abundance and distribution of fisheries resources of the northeastern United States continental shelf. *U.S. Geological Survey Open File Report* 91-439: 25p.

[80] D. Roddick, Halifax Fisheries Research Laboratory, Department of Fisheries and Oceans, *personal communication*. This research remains unpublished. A convenient introductory explanation of ROXANN and its use in another seabed habitat survey can be found in: Magorrian, B.H., M. Service & W. Clarke (1995) An acoustic bottom classification survey of Strangford Lough, Northern Ireland. *Journal of the Marine Biological Association of the United Kingdom* 75: 987-992.

a topographically relatively flat and oceanographically high-energy area, the top of Banquereau would be expected to be less spatially variable than, say, the sides of the Sable Gully, where patch sizes would therefore be smaller. Natural environments contain hierarchies of patches within larger patches but, if there is detectable patchiness on a scale of about 200 m on Banquereau, there is probably significant patchiness along the proposed SOEP offshore pipeline routes on scales of the order of 100 m.

While the spatial heterogeneity of the seabed is hard to see, even with advanced equipment, and difficult for the average person, lacking a fisherman's intimate understanding, to comprehend, it is now clear that the sea floor environments on the Scotian Shelf are little less variable than the terrestrial environments of Nova Scotian woodland. Instead of stands of different kinds of trees, intermixed with bogs and barrens, there are beds of different kinds of benthic animals and patches of sand, mud and stones. The spatial scales of the patches on land and in the sea are not, however, much different and there is the same need for fine-scale survey information in both.

The Proponents have attempted to deny this need, presenting a mixed array of arguments in doing so[81]:

- That the EIS already examined benthic resource species – a point that was never in doubt[82]. The problem is the spatial resolution of that examination.
- That, aside from resource species, no endangered species or benthic communities of special ecological significance have been identified in the area – a point that again has no relevance to spatial scales of habitat patches.
- That the benthic communities would not be affected by a blowout – a correct but irrelevant contention.
- That pipeline construction would only affect a narrow corridor – a debatable point, for the issue at hand, since the relative width of the corridor depends on the sizes of the habitat patches that it would cross.
- That the variability of benthic communities is so high that even an extensive survey would not influence the outcome of the Proponents' assessment – a comparison which better tests the value of their EIA than that of such a survey.

Aside from pure commercial expediency, the only valid argument against the necessity for fine-scale habitat information that this writer can see is that the small environmental patches offshore may represent multiple, inter-mingled copies of a few basic habitat types. If so, one might decide that it is acceptable to obliterate a few hundred 10 m diameter patches of "Type A" by trenching them for a pipeline, since there would be some millions of other, almost identical, patches elsewhere on the Scotian Shelf. If, on the other hand, there is a "Type Z" patch on the pipeline route and only a handful of other examples of the type elsewhere in the northwest Atlantic, one might decide that the pipeline should be routed

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ROXANN makes some crude analyses of echosounder data to provide an indication of the nature of seabed sediments. While the meaning of the output information is unclear, in geological terms, it does reflect habitat type well enough to be relied upon by surfclam fishermen for targeting their effort (M. Pittman, Deep Sea Trawlers, Lunenburg, Nova Scotia).

[81] *SOEP Responses to Scoping Process* p. 12.

[82] Though the Proponents seem to have given no heed to the one kind of small seabed patch that has long been known and is of commercial importance – herring spawning beds. They seem to have made no effort whatsoever to discover whether there is such a bed in the vicinity of their pipeline corridor near Country Harbour.

around the patch. That would be a likely decision in the case of an onshore pipeline and a small patch of rare plants. Equally, if there was an offshore patch of "Type B" that was moderately common but of particular importance to the commercial fishery, perhaps as an area where cod congregate, one might decide to route the pipeline around it; especially if there were only one or two other examples within the array of grounds traditionally fished by small-boat fishermen from a particular port. Again, such a decision would be normal in an equivalent situation on land.

The Problem facing the SOEP Proponents and those reviewing their proposal is that no information on the number of different types of habitat patches on the Scotian Shelf, nor on the frequency of each type, has yet been gathered. It is likely that some patch types are replicated many times. It is, however, also likely that some types are rare – just as would be expected on land. Furthermore, it is also likely that some of these rare patches are dominated by rare species and even species as yet unknown to science[83]. Such a patch might well be declared a community of "special ecological significance" once its nature was recognized. Unfortunately, there is no catalogue of this information against which to compare the results of a site-specific survey and thus the Proponents' final point, quoted above, is partly correct – a great deal of effort could be expended, using state-of-the-art equipment, to map the habitats along the pipeline routes at high resolution and yet (without more extensive surveys elsewhere on the eastern Scotian Shelf) it would be difficult to judge the significance of the mapped information.

The Panel and other parties to its review thus face a dilemma: Knowing that the seabed habitats within the Proponents' offshore pipeline corridors are spatially heterogeneous, suspecting that some of the patches are rare and contain rare organisms but knowing that a proper mapping of sensitive areas (such as might be done on land) would stretch current scientific capabilities, is it acceptable to lay a pipeline across those habitats without first making reasonable efforts to map them and to route the pipeline around those which seem least desirable to destroy? Given that the SOEP Proponents have submitted an EIS for their proposed pipelines without making such efforts, and indeed without defining specific pipeline routes, is it appropriate <u>in this case</u> to now require high-resolution habitat surveys along likely routes? These are not questions for which there are scientific answers.

3.2.2 Potential Impacts of Pipelaying

Even though the pipeline routes are undefined and the habitats that they would cross remain unknown, there would be no need for environmental concern over the pipelaying if that process was harmless to the environment. Unfortunately, it is not clear that that is so[84].

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[83] In the seas around the British Isles, where the composition of the marine fauna has been studied far more intensively than off Nova Scotia, new species are still being added at an appreciable rate [Costello, M.J., C.S. Emblow & B.E. Picton (1996) Long term trends in the discovery of marine species new to science which occur in Britain and Ireland. *Journal of the Marine Biological Association of the United Kingdom* 76: 255-257]. Few of those new species are large but they are macroscopic metazoans, such as polychaete and nematode worms or nudibranch molluscs. The protozoan, bacterial and viral communities in the ocean are almost unknown but can, perhaps, be left that way for now.

[84] The Ecology Action Centre's *Information Request* 8b was an attempt to discover whether the Proponents knew of any actual evidence for the environmental effects of marine pipelines or the absence of such effects, since the present writer had been unable to discover any relevant studies. The Proponents' submitted reply (*SOEP Response to Ecology Action Centre Information Request* 8b) seems to have been prepared in answer to some other question and does not deal with pipelines at all. They did not offer any response to *Ecology Action Centre Information Request* 8c.

3.2.2.1 Pipeline Construction – Trenching and Blasting

3.2.2.1.1 The SOEP Proposal

As with the pipeline routes, the Proponents have not committed themselves to the specific form of pipe laying that would be used in various places – whether simple placement on the seabed, laying into a dug or blasted trench, post-laying burial, or even placement on the seabed and subsequent covering with protective material. In the EIS, they expressed an expectation that the inter-field pipelines would all be trenched and left to self-bury, whereas the *Thebaud*-Country Harbour pipeline would receive that treatment only in shallow areas along its length. In the shallowest waters in Country Harbour, it has been said that the trench would be backfilled. The pipe would pass ashore either in a backfilled trench or else in a drilled approach tunnel. The trenching process would be performed by either mechanical dredging, ploughing, jetting or dragging, depending on seabed and ecological conditions. Nearshore, it was anticipated that there might be some blasting of rock outcrops[85]. Various potential precautions which, if used, might reduce any environmental impacts were listed[86], though without any evident binding commitment, on the Proponents' part, that they would be employed and without any discussion of their efficacy in waters like those of Country Harbour.

When the Panel requested additional information on the trenching methods to be used in the nearshore zone, the Proponents revealed further options: coating the pipe with additional concrete, leaving it proud of the seabed and declaring a no-anchoring area around it, or else leaving it proud and covering it with protective material[87]. Offshore, the Panel's questions were more concerned with backfilling of trenches, scour and seabed stability. That generated the response, from the Proponents, that backfilling might be needed near the platforms and perhaps in some "hard bottom" areas, along with more details of criteria to be considered in selecting areas where trenching would be required[88]. Taken together, this varied information paints a general picture of the nature of the likely pipelaying operations, though without providing any firm specifics on the Proponents' intentions.

3.2.2.1.2 Impacts of Pipelaying

Simply laying a pipe on the seabed does little more than occupy space, and little of that, though subsequent natural processes could cause scouring of the seabed or its converse, sedimentation, as the pipe altered local water flows. No estimate of the area potentially affected has been provided, though it seems unlikely to extend as much a few metres to either side of the pipe and then only at intervals along its length. Strangely, the Proponents do not appear to acknowledge this scouring and sedimentation as a possible effect on the environment[89], even though, due to the great length of un-trenched pipeline that they seem

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[85] *SOEP Volume 3 – EIS*, pp. 3-10, 3-12, 3-24 & 6-22; *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, pp. 3-3 to 3-4; *SOEP Response to Panel Information Requests* 2.31 & 4.9.
[86] *SOEP Volume 3 – EIS*, pp. 7-5 & 7-6; *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, p. 3-3.
[87] *SOEP Response to Panel Information Requests* 2.31ai
[88] *SOEP Response to Panel Information Request* 2.34. Further information on the trenching of offshore pipelines appears in *SOEP Response to Panel Information Request* 2.35.
[89] They do touch on it as an effect of the environment on the pipeline, leading to unsupported spans of pipe and hydrodynamic loadings (*SOEP Volume 3 – EIS*, p. 6-23).

to intend laying, it could affect a larger spatial area than all other pipeline-associated effects combined.

Trenching, by whatever means it is achieved, would disturb seabed sediments and allow them to spread over the adjacent seafloor, with minor and local effects on the surrounding biota[90]. The various barges used in pipelaying must also be anchored, causing further but lesser disturbance to the seabed. In the Proponents' EIS, this trench-related sedimentation is only noted as a problem in the outer parts of Country Harbour and only for scallops[91], though it would also occur offshore and apply to a much wider variety of organisms. In neither area, however, does sedimentation *per se* seem likely to be sufficiently severe to have any but the mildest and most transient impact.

Blasting, which might be required inshore in bedrock areas, would have a more serious environmental effect, with destruction and disturbance of a variety of organisms and habitats. The actual lethal effect of the blast would be so limited in space and time that its effects would have to be deemed insignificant by any reasonable standards. Behavioural disturbance of fish could be more of a concern, however. Indeed, if the blasting occurred during a season when there was a fishery in the immediate vicinity of the blast site, catches could be depressed for a number of days – as the Proponents have recognized (though their recognition of it extends only to lobstering)[92]. Since there should only be a minimal amount of blasting for the SOEP pipeline, and that only within Country Harbour, cooperation and consultation between the Proponents and local fishermen should be sufficient to reduce the direct effects to negligible levels.

Trenching and blasting would, however, raise additional concerns if the material disturbed on the seabed was itself harmful. This is not a realistic concern offshore but, within Country Harbour, there is some small risk of either disturbing sediments contaminated with heavy metals, derived from old mine tailings, or else of releasing the dormant cysts of organisms which, should they bloom, would cause potentially-deadly (for humans) Paralytic Shellfish Poisoning (PSP). Neither eventuality seems likely but, with aquaculture operations nearby and a commercial fishery operating astride the pipeline corridor, they cannot be ignored – not have they been. The Proponents are subject to Environment Canada's Ocean Dumping regulations, which closely control dredging and disposal of contaminated sediments. Further sampling in Country Harbour is planned and, should that show contamination above accepted limits, the Proponents appear to intend using various mitigating measures to meet the permitted levels of contaminant release[93]. If this process worked effectively, it should ensure that no unacceptable amount of any pollutant entered the water column. Whether its effectiveness could be relied upon, in the event that the Proponents first received approval from the Panel to build a gas plant on their chosen site and then found heavy metals in the only available pipeline corridor, is another question entirely. Thus, the risk of contamination from this source, while small, remains unresolved.

[90] Drilling, if such should be used to pass the pipeline ashore, would not disturb sediments but could result in some minor loss of bentonite and other drill mud constituents (*SOEP Response to Panel Information Request* 4.9b). These might affect a slightly different area from the one vulnerable to a trenched approach but it would still be very small. Only if the drill mud contained toxic materials need there be any cause for concern and even then the shallow depth at the end of the drilled approach should allow effective containment and clean-up.
[91] *SOEP Volume 3 – EIS*, p. 6-20.
[92] *SOEP Volume 3 – EIS*, p. 6-22.
[93] *SOEP Response to Panel Information Request* 4.13.

The PSP issue is even less clear. The likelihood of a toxic bloom has always been considered, by all parties, to be low – though localized PSP problems have been known to arise under unexpected circumstances[94] and the possibility of a problem at Country Harbour should not be lightly dismissed. The Proponents initially stated that "no significant blooms of PSP-causing organisms have been reported previously for the Atlantic Coast of Nova Scotia"[95]. They also suggested that a pre-dredge survey could reduce the likelihood of a PSP problem (though how was not explained), while compensation could remove any residual impact[96]. In their *Gas Plant and Nearshore Pipeline Assessment* addendum, the PSP issue was then dismissed on the grounds that "no significant blooms of PSP-causing organisms have been reported to date for the Atlantic Coast of Nova Scotia" and that the conditions that would lead disturbed cysts to cause a bloom are unlikely[97]. The ideas of a survey or of compensation seem to have been forgotten. The occasional occurrence along the Eastern Shore of *Alexandrium tamarense*, one of the PSP-causing organisms, was subsequently pointed out to the Proponents, though the likelihood of pipeline trenching provoking a bloom of sufficient magnitude to cause toxicity was apparently still evaluated as "extremely unlikely" by DFO's specialist in these matters, Dr. J. Martin (St. Andrews Biological Station).

There is, in any case and as the Proponents have pointed out, no practical way in which the chance of a PSP outbreak could be further reduced[98], short of not bringing the pipeline ashore in Country Harbour at all – an option which the Proponents do not seem to have considered. What they could have done, but show no evidence of having undertaken despite encouragement[99], was to discuss PSP incidence with officials of DFO's Inspection Directorate (now being transferred into the new unified food inspection agency) who routinely monitor for PSP along this coast as part of their Canadian Shellfish Sanitation Program. Such discussions would have produced information on the incidence and distribution of PSP blooms and the resulting shellfish closures along the Atlantic coast of this Province, together with site-specific data from the standard PSP sampling site in Country Harbour[100]. Compilation and presentation of such information would have allowed some better estimation of the risks involved in the SOEP proposal. Those risks are likely very small and any adverse effect could be addressed through enhanced monitoring followed by compensation, if required, but it is still unfortunate that available information has not been placed before the Panel.

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[94] One such example has been recently reported by: McKenzie, C.H., R.J. Thompson, C.C. Parrish, J. Helbig, E.A. Hatfield & B. deYoung (1996) *Alexandrium* cysts in coastal cold ocean sediment and their role in bivalve aquaculture management. *In:* R.W. Penny (*ed.*) Proceedings of the fifth Canadian workshop on harmful marine algae. *Canadian Technical Report of Fisheries & Aquatic Sciences* 2138: 135-137.
[95] *SOEP Volume 3 – EIS*, p. 6-22.
[96] *SOEP Volume 3 – EIS*, Table 7.7-1.
[97] *SOEP Gas Plant and Nearshore Pipeline Assessment*, pp. 6-10 to 6-12, Table 6.3-1.
[98] *SOEP Response to Panel Information Request* 4.14.
[99] *Ecology Action Centre Information Request* 19. In that *Information Request* it was erroneously stated that the Proponents had recognized the occurrence of PSP on the Atlantic Coast. In their *Response*, the Proponents correctly pointed out that it was the occurrence of PSP-causing organisms, rather than of PSP, that they had recognized.
[100] Bates, S.S. & P.D. Keizer (1996) Proceedings of the workshop on harmful algae research in the DFO Maritimes Region. *Canadian Technical Report of Fisheries & Aquatic Sciences* 2128: 44p.; Stephen, S.J. (1996) Marine biotoxin shellfish monitoring in Canada's new food inspection agency. *In:* R.W. Penny (*ed.*) Proceedings of the fifth Canadian workshop on harmful marine algae. *Canadian Technical Report of Fisheries & Aquatic Sciences* 2138: 117.

After all of the debate on these lesser trenching topics, however, there is still the question of the trenches themselves, which the Proponents seem reluctant to address[101]. The area of actual disturbance (as distinct from that experiencing sedimentation, which would be wider) is said to be on the order of 15 m either side of the trench centreline[102]. Even the Proponents recognize that, with their chosen pipeline route inside Country Harbour, this would cause a short-term loss of 25,000 m^2 of good lobster fishing ground, though natural processes should restore the original habitat quality over a few years[103]. What they do not remark on, however, is the much larger area of productive fish habitat potentially lost to trenches along the other 200 and more kilometres of submarine pipelines that they propose to lay[104]. Much of that distance would not, of course, be trenched and some that was would be in mobile sand, where the natural seabed habitat may be restored within months. Other trenches, however, could be in harder bottom, where the pipeline crossed bands of glacial till (a random mixture of sediments from mud to boulders known, in this area, as "Scotian Shelf Drift"[105]). The immediate surface of such sediments is typically composed of a stony lag deposit from which mud and silt particles have been eroded by wave action[106]. Breaking that layer, which is only a few centimetres thick, would expose the finer sediment below to erosion, thus greatly magnifying the original habitat damage of the trench itself[107].

It is this sort of area-specific effect that an EIS of an offshore pipeline proposal should address and which the Proponents, for all their discussion of PSP, blasting and other minor impacts, have avoided. Without details of where they propose to lay their pipelines, what habitats occur along those routes and what trenching methods would be employed in various places, it is impossible to assess their proposal. Without that information, no claim that laying these pipelines would be unacceptably harmful can be supported but neither can any claim that it would not be.

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[101] See, for example, the list of possible effects of trenching given in *SOEP Response to Panel Information Request* 2.31c, which includes four minor potential impacts but not the 30 metre-wide scar cut into the seabed.

[102] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, p. 3-3. This may, however, be a maximal value, reached only at the deepest points of the trench. Even then, it might be reducible by ploughing, though that is only possible on soft sediments (*SOEP Response to Panel Information Request* 4.10b).

[103] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, p. 6-10; *SOEP Response to Panel Information Request* 4.10b.

[104] Indeed, they do not even address the issue of the full amount of lobster habitat in the Country Harbour area that their trenching would disrupt, confining themselves to that part of such habitat which the lobsters occupy during the regulated fishing season.

[105] King, L.H. 1970. Surficial geology of the Halifax-Sable Island map area. *Geological Survey of Canada, Marine Science Paper* 1: 16p.

[106] MacLean, B. & L.H. King (1971) Surficial geology of the Banquereau and Misaine Bank map area. *Geological Survey of Canada, Marine Science Paper* 3: 19p. Their Plate 6 shows the type of lag deposit in question.

[107] This mechanism has been invoked to explain the claimed effect of mobile fishing gear on some seabed habitats off Nova Scotia (G. Fader, Geological Survey of Canada, Bedford Institute of Oceanography, *pers, comm.*).

3.2.2.1.3 Discharge of Hydrostatic Test Fluid

In order to pressure-test the completed pipelines, they must be filled with liquid and pressurized[108]. Following testing, the test fluid must be purged, leaving the pipe ready for service and without internal corrosion. The easiest way to purge the test fluid is probably by letting the natural gas flow through the pipeline at normal working pressure, with a train of pigs being passed through to force out all of the liquid.

Where the inter-field pipelines are concerned, the volumes of each pipe (and hence of the contained test fluid) are only moderate and the most convenient discharge point, *Thebaud*, is in the open sea[109]. Release of the test fluid can, therefore, be ranked with the other minor chemical discharges: not necessarily harmless but carrying too low a probability of harm to merit much concern alongside the larger impacts of the SOEP proposal (see Section 7). The test fluid from the main *Thebaud*-to-Country Harbour pipeline would, however, be of much greater volume and, if purged from the pipe using the pressure of gas from the *Thebaud* wells, would be discharged into the confined waters of Country Harbour, where its dispersal would be much more limited than it would be offshore. This discharge has, in consequence, received some considerable attention.

The Proponents originally suggested using as hydrostatic test fluid either fresh or salt water, with the addition of oxygen scavengers, corrosion inhibitors, biocides and marker dyes. The total volume was said to be 50,000 m^3. The Proponents dismissed the potential impacts of such a discharge as “minor”, with no residual impact, on the grounds that methods, such as discharge on an ebb tide during a period of offshore winds, were available that would minimize the chance of the test fluid reaching aquaculture operations, already some 5 km up the Harbour from any likely discharge point[110]. They did not commit themselves to using such mitigation, nor did they explain how it would prevent damage to the natural biota, including commercial fish resources, of the outer basin of the Harbour. They did commit to monitoring the discharge to ensure that it was adequately diluted[111], though if the monitoring should show that appropriate dilution had not occurred it would, by then, be rather too late to protect vulnerable biota or to recover the test fluid for disposal by other means.

In response to an Information Request from the Panel, the Proponents have since explained that untreated fresh or salt water could be used for the pressure testing, if the pipe was to be

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[108] Such “hydrostatic” testing relies on the incompressibility of water. If the pipe failed under test, the resulting drop in pressure would be accommodated with minimal expansion of the contained test fluid. If the same testing was performed using (compressible) gas, the drop in pressure following a failure would be accompanied by explosive expansion of the gas – a dangerous and destructive outcome. The SOEP Proponents have, nevertheless, suggested that they will consider pneumatic testing (using a gaseous test fluid: *SOEP Volume 3 – EIS* p. 3-59).

[109] *SOEP Response to Panel Information Request* 4.15b seems to imply, however, that the test fluids from the *Venture* and *North Triumph* inter-field pipelines would be passed through the main pipeline for eventual discharge at Country Harbour.

[110] *SOEP Volume 3 – EIS* pp. 3-59, 3-62 & 6-22, Tables 6.4-1 & 7.7-1; *SOEP Addendum 2 – Gas Plan and Nearshore Pipeline Assessment* pp. 6-10 & 7-4; *SOEP Response to Panel Information Request* 4.15. Subsequent design changes have increased the *Thebaud*-to-Country Harbour pipeline diameter to 660 mm, while its length has been estimated at 208 km (*SOEP Addendum 2 – Gas Plan and Nearshore Pipeline Assessment* p. 3-3). Using those dimensions, the volume in question is more than 70,000 m^3. (The Proponents’ most recent public estimate of the total volume of hydrostatic test fluid, probably including that in the inter-field pipelines, is 80,000 m^3: *SOEP Response to Panel Information Request* 4.15b.)

[111] *SOEP Addendum 2 – Gas Plan and Nearshore Pipeline Assessment* p. 7-4.

emptied soon after. Discharge of such untreated water from the pipeline would not be without any environmental effect but it is only the release of treated water that need be of real concern. Such treatment would, it was stated, only be needed if the water was to be left in the pipe for an extended period. Even if it was used, the treatment chemicals could apparently be neutralized before, or as, the fluid was released. And, despite the apparent lack of any quantitative information on rates of mixing and dispersal in Country Harbour, the Proponents have stated that the fluid would be sufficiently diluted as not to cause any harm[112].

In response to further questioning by the Ecology Action Centre, the Proponents then seem to have committed themselves (subject to regulatory approval) to ensuring that the concentration of the fluid dispersed in seawater, 500 m or more from the discharge point, is not greater than 1% of the 96 hr LC_{50}[113]. If achievable, that may well be an acceptable level of impact. It is not, however, clear how the Proponents would determine the degree of dilution and dispersal of the fluid, without extensive oceanographic studies in Country Harbour. Without rather complex modelling, a discharge calculated to achieve no more than 1% of the 96 hr LC_{50} at 500 m might prove, in practice, to result in much more toxic conditions at that range from the discharge point. Besides, setting a limit on the toxicity of a discharge 500 m from an outfall does little for organisms living closer to the pipe, nor for species more sensitive than the (un-specified) standard used in defining the LC_{50}. In short, the Proponents' commitment should prevent gross and widespread environmental damage but might not reduce such damage to acceptable levels.

This entire concern could be removed if the Proponents would only undertake either to discharge the fluid at *Thebaud* or to use only clean seawater for the testing. The former would require the additional expense of blowing the pipeline clear from the landward end, while the latter would involve careful scheduling to ensure that the production flow of gas could commence immediately after hydrostatic testing – with the potential for high costs of delays if the pipe should fail its test after the rest of the project were ready to ship gas to market. Expensive though either option might be for the Proponents, there does not seem to be sufficient reason to subject Country Harbour to the discharge of a very large volume of toxic fluid just to ease the technical difficulties of bringing SOEP into production.

3.2.2.1.4 The Proponents' Assessment

In their EIS Impact Assessment Matrix, the Proponents accepted as a "significant impact" of pipeline construction only the risk that disturbed sediment might affect aquaculture operations in Country Harbour, though they perhaps intended that with more reference to the PSP issue than to simple turbidity in the water column. Otherwise, they then considered that blasting, contamination of surface waters (aside from the effect on aquaculture), the necessary temporary exclusion zones around the pipelay barge and the discharge of hydrostatic testing fluid would only have insignificant effects[114]. By the time that the *Gas Plant and Nearshore Pipeline Assessment* addendum was prepared, and then with exclusive reference to Country Harbour, "exclusion of fishing activity" had ceased to be a pathway

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[112] *SOEP Response to Panel Information Request* 4.15.

[113] *SOEP Response to Ecology Action Centre Information Request* 20. The Proponents did not respond to part (b) of this *Information Request*, which sought information on non-lethal effects of discharging these hydrostatic test fluids.

[114] *SOEP Volume 3 – EIS*, Tables 6.4-1 & 7.7-1. Although dismissed in Table 7.7-1 as having no residual impact, disturbance of "contaminated sediments" by trenching in Country Harbour was listed as one of only six pathways leading to residual impacts in Table 7.7-3. The EIS offers no explanation for this anomaly.

leading to possible impacts but "habitat disturbance" and "sedimentation" had been added, while disturbance of contaminated sediment had expanded to include some small risk of heavy metal contamination. None of these possible impacts were considered "significant" – the PSP issue having been relegated to insignificance[115]. A range of possible mitigation measures were outlined and the Proponents invoked the provisions within DFO's "No Net Loss" habitat policy that do permit uncompensated net loss, which led them to the conclusion that there would only be insignificant residual impacts[116].

Of themselves, these judgements seem eminently reasonable. They are not, however, sufficiently certain to be accepted without question. Nor do they address all of the concerns over pipeline construction. Indeed they do not even consider the major such concerns, which lie offshore – where the majority of the pipelaying and the most productive habitats along the pipeline corridors both lie.

3.2.2.2 Cultural Resources

Besides all of the potential effects on the natural environment discussed above, there is also some reason for concern over the impact of pipelaying on cultural resources. In the absence of evidence for palaeo-indian archaeological sites on the Scotian Shelf, that amounts to a concern over shipwrecks. The Proponents have routed their pipeline corridor so as to avoid the known wreck sites in Country Harbour[117] and they will no doubt ensure that the pipe is not laid directly over any steel debris offshore that might damage it. Wreck sites of an age to have archaeological value, being composed largely of wood and likely buried in sediment, would not however pose any danger to the pipe. Nor would they be expected to be detected by any of the geotechnical, SWATH or sidescan surveys undertaken by the Proponents[118]. This, the possibility of irremediable damage to cultural resources remains.

Ideally, the Proponents might be asked to run pipeline route surveys with acoustic equipment capable of detecting buried wooden wreck sites but (in contrast to the pipeline corridor across the Strait of Canso: see Section 10.1.3) the expected density of shipwrecks in offshore areas, and indeed in Country Harbour too, is probably so low as to render such surveys unnecessary. The risk of damage, while present, can perhaps be accepted.

3.2.3 Long-term Impacts of Pipelines

Once the marine pipelines had been laid, and barring any accidents, their operation should have no effects on the surrounding environment[119]. The presence of the pipeline would however have an impact on fishing activities and hence on the environment. At the time of writing, the Proponents have yet to decide whether they would require formal fishing

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[115] *SOEP Gas Plant and Nearshore Pipeline Assessment*, pp. 6-10 to 6-12, Table 6.3-1.

[116] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, pp. 7-2 to 7-4, Table 7.4-1. Why a project like SOEP should be excused from DFO's normal requirement to mitigate any habitat loss by enhancement elsewhere is unclear.

[117] *SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment*, Table 5.5-1.

[118] cf. *SOEP Response to Canadian Coast Guard Information Request* 1.

[119] An *Information Request* from DFO did raise the intriguing question of noise from the flow of gas in the pipes. While there does not seem to be much evidence of the intensity of this sound and no consideration seems to have been given to the noise of pigs travelling through the pipe, the Proponents' conclusion that noise levels are very low does seem likely (*SOEP Response to DFO Habitat Management Division Information Request* 2).

exclusion zones around some or all of their marine pipelines[120]. Trenched and buried pipelines should pose no obstacle to fishing and the main *Thebaud* to Country Harbour pipe should withstand even heavy contact by offshore fishing gear without damage[121], thus it is possible that no specific exclusion zones would be required by the Proponents. Prudent captains of mobile-gear fishing boats might, however, choose to avoid areas near exposed pipes, in order to protect their gear and their crew, even if they were under no legal obligation to do so. Thus, an informal exclusion zone could appear, even if a formal one did not. Either kind would, of course, involve some loss of fishing ground and hence of potential income.

The emergence of such a zone might then allow a gradual re-establishment of benthic epifauna, free of the effects of dragging[122]. This could add to the possible "reef effect" resulting from the "hard substrate" provided by the pipe itself (see Section 3.1.2). Not only might this increase the net production of fish, in the manner of a closed area, but the linear strip of enhanced habitat (should it appear) could become a preferred area for longline fishing: free of the threat of gear conflicts with draggers and offering the environments within which cod and haddock are more inclined to take a baited hook. Thus, the presence of exposed offshore pipelines might lead to some net benefits to the marine environment and the fisheries, as partial compensation to the degradation elsewhere. Whether those benefits would be of significant magnitude must remain a matter for speculation.

3.3 Summary

Once again, the primary conclusion of this Section is that the information provided and analyzed by the Proponents was inadequate to support a valid EIA or a rational decision on the merits of their proposal. This is not simply a question of deficient process, however, and the construction phase of SOEP would cause a number of minor and some potentially not-so-minor impacts on the marine environment. Aside from those which seem truly negligible and those which would be swamped by the greater effects of other phases of the project, these impacts would include (but not necessarily be limited to) the following:

- Pile driving during the placement of the platform jackets would emit loud underwater noise, with effects akin to, but milder than, those of seismic surveys.
- Cutting of trenches for offshore pipelines, plus scour and deposition around laid pipe, would disrupt a considerable seabed area. While that area would be a tiny fraction of the total in the SOEP study area, it could include a substantial proportion of some of the less-common habitat types on the Scotian Shelf.
- These actions could similarly disrupt habitat types used as commercial fishing grounds, potentially including a high proportion of the grounds available to some small-boat fishermen.
- Mobile-gear fishermen may lose some present fishing area, as a result of *de facto*, if not *de jure*, exclusion zones around the pipelines.

[120] *SOEP Response to DFO Habitat Management Division Information Request* 8.
[121] Gillis, G.G. (1984) Influence of scallop rakes on submarine pipelines: Full scale on-land tests. *Report filed with Panel by the Proponents.*
[122] The extent to which mobile-gear fishing currently degrades seabed habitats is a matter of vociferous debate. Suffice to say that if such fishing was excluded from a zone around the pipeline, there might be a recovery of habitat quality which might lead to increased fish production.

- Trenching in Country Harbour may yet disturb either contaminated sediments or PSP-causing organisms, to the detriment of the fishing and aquaculture industries or the natural biota of the area.

These negative effects might be partly counter-balanced by enhancement of the environment through the “reef effect”, with both the platforms and, more especially, the pipelines serving as “reef” structures.

If SOEP was followed by expanded offshore petroleum activities on the eastern Scotian Shelf, each of these impacts might be repeated in other areas. However, the most likely immediate successors to SOEP, as well as any extension of SOEP itself, would probably be planned around the use of the *Thebaud*-Country Harbour pipeline – that being the central installation, the existence of which would facilitate the further development. Thus, the extent and degree of construction impacts from follow-up projects would be relatively less than those of SOEP.

4. Shipping and Helicopters

All phases of SOEP would involve some activity by both ships and aircraft. While the details of that activity would doubtless continue to evolve, the Proponents have provided information on their current expectations which seems generally adequate for the purposes of the Panel's review[123].

4.1 Overall Level of Activity

According to the Proponents' estimates, during construction, there would be periods when about ten vessels would be working together offshore, including a heavy lift vessel (of up to 150,000 tons[124]) and its attendant support craft, while a pipelay vessel (of up to 30,000 tons) and a few additional support craft would be need to lay the offshore pipelines. During drilling and production, however, the total number of ships involved would drop to at most ten, each of which would be around 3,000 tons in size[125] – similar to the support vessels currently servicing the COPAN fields from their base in Halifax. This total does not include the condensate tankers, nor the possible butane barges, operating from the proposed liquids plant at Point Tupper. The Proponents do not appear to regard those as parts of the SOEP development, though their voyages will not occur unless the project proceeds and thus they should be included in the Panel's review. Each tanker would carry some 500,000 or even 1,000,000 bbl of condensate per load[126], the latter requiring a ship of around 200,000 tons deadweight.

There would be periods during construction when the SOEP vessels would make an average of about a half-dozen arrivals per day in Nova Scotian harbours, with as many departures also. For much of the life of the project, however, that average would drop to below one per day. Meanwhile, one or two helicopters would support the work, with a maximal rate of around three flights from the mainland and back every two days and a typical frequency well below even that[127].

These totals would obviously comprise only a tiny increment to the marine and aviation activities in the area between Halifax, Sable Island and the Strait of Canso and, as an overall total, they need be of no special environmental concern whatsoever. The condensate tankers, and possible butane barges, would involve special dangers of spills in the event of

[123] *SOEP Responses to Scoping Process* pp. 22-26. (A briefer version of the same information had been provided in *SOEP Volume 2 – DPA*, Section 5.4.3 and some extra details have been given in *SOEP Response to Province of Nova Scotia Information Request* 1.32.) While no more precise than the information on some other aspects of SOEP, that provided on shipping and aircraft activity is sufficient to bound its possible environmental effects. Other SOEP activities require more detail to reach the same degree of understanding of their impacts.

[124] The Proponents do not state what form of tonnage their figure refers to. A "150,000 ton" tanker, which would not be unusual in Halifax Harbour, is one with a deadweight tonnage of that amount (i.e. that is the weight of cargo it can carry). Other forms of mercantile shipping are, however, usually referred to by their gross tonnage – a measure of enclosed volume. A 150,000 grt ship would be very large indeed; possibly larger than any ship that has ever visited a Nova Scotian port, though still much smaller than the world's largest tankers.

[125] *SOEP Responses to Scoping Process* pp. 22-26.

[126] *SOEP Volume 3 – EIS* p. 3-82; *SOEP Response to Panel Information Request* 1.4a.

[127] *SOEP Responses to Scoping Process* p. 24.

an accident. Those are addressed elsewhere in this report (see Section 6). There would also be some increased risk of a marine accident involved in ships working in close proximity offshore (relative to typical operations of mercantile shipping) during the construction phase but SOEP should not involve any unusual problems from the specialized perspective of the offshore construction sector. Experienced operators should be able to carry out the work without any elevated risks. Thus, aside from issues relating to all shipping and aircraft, which are probably beyond the scope of the Panel's review, the overall level of marine and aviation activity is too low to raise any environmental concerns.

4.2 Site Specific Effects

4.2.1 Areas Impacted

The only other grounds for environmental concern over these SOEP activities relate to their specific locations. At the mainland end of each trip, both ships and aircraft are likely to operate from established ports and airports. While this activity might have substantial effects onshore, there should be no special effects (beyond those common to all marine and aviation operations) on the marine environment. Only if political or other factors induced the Proponents to establish their offshore support base in an undeveloped (or under-developed) harbour, such as Sheet Harbour, Country Harbour or Canso, would additional issues need to be considered. As yet, there is no indication that the Proponents are considering any such option, though it has not been specifically and publicly ruled out[128]. Nor would the shipping routes from the mainland to the Sable Island vicinity pose any special concerns. The area crossed is routinely traversed by many vessels: container ships from Halifax to Europe, Canadian naval units, assorted fishing craft and many others. The addition of the SOEP shipping to this mix would not cause a noticeable increase. Thus, the only substantial concern would be for an increase in shipping and aircraft in the vicinity of Sable Island and the Sable Gully, where big ships are less frequent and where the SOEP "fleet" would be concentrated.

4.2.2 Ship and Whale Collisions

In the Sable area, aside from the normal range of minor environmental impacts of shipping[129], there are questions of collisions between ships and marine mammals, and of the noise produced by ships and aircraft. As the Proponents have noted[130], it is right whales that are most at risk of collisions with ships because of their slow, surface-swimming behaviour. While the losses of these endangered animals to ship collisions are a very serious problem indeed in the Bay of Fundy, and elsewhere off southwest Nova Scotia, right whales are not regularly found near Sable Island or the Sable Gully and the

[128] cf. *SOEP Response to Panel Information Request* 3.10. Should a decision be taken to develop a supply base in such a "new" harbour, a number of environmental questions would have to be answered. They are not addressed in the EIS.

[129] Such as the risk of marine accidents resulting in spilt diesel fuel, or the routine discharge of traces of hydraulic fluid, of galley wastes and the like. Floating debris from shipping, particularly discarded fishing gear, has been identified as a major hazard for the bottlenose whale population in the Sable Gully [Faucher, A. & H. Whitehead (1995) Importance of habitat protection for the northern bottlenose whale in The Gully, Nova Scotia. *In:* N.L. Shackell & J.H.M. Willison *Marine Protected Areas and Sustainable Fisheries.* SAMPAA, Wolfville: 99-102].

[130] *SOEP Response to Panel Information Request* 4.4. There is no apparent mention of these collisions in the Proponents' EIA.

risk of collision with them is not a major issue there. Other types of cetaceans will usually either stay well clear of ships, which they are usually fully capable of avoiding, or else (in the case of the smaller odontocetes) will deliberately choose to ride the bow wave. Seals are equally adept at maintaining a safe distance from human activities. Accidents, on the part of the whale (or seal) as well as that of the ship's officers, certainly do occur –sometimes with fatal consequences for one party of the other– and thus there is some chance of a fatal collision between a SOEP ship and a whale during the life of the project. However, from both general experience and the fact that most of the SOEP shipping activity will be at some distance from any major concentrations of whales (though not those of seals), the overall risk must be small. The Proponents' contention that the risk of a collision is minimal[131] does seem, to this writer, to be justified.

Nevertheless, and to their credit, the Proponents have already stated that their Code of Practice would keep all regular SOEP shipping activity outside the Canadian Wildlife Service's proposed whale sanctuary area in the Gully, as well as outside the areas between the SOEP platforms and Sable Island, while SOEP aircraft would also be routed away from those areas[132]. This commitment is weakened by its reference to "regular project-generated" traffic, which could be construed as not excluding ships engaged in seismic surveys or platform construction from the named areas. It is further weakened by having an objective which is stated as only "to protect the Gully from *needless* vessel traffic" [emphasis added]. It would certainly be better if the Code was re-phrased to apply to all non-emergency situations, if it was binding on SOEP and if its implementation was subject to oversight by a stakeholder committee. It would also, of course, be better for the cetacean populations in the Gully if the exclusion zone was further expanded. Even without such changes, however, the risk of collisions with whales would seem very small.

4.2.3 Ship Noise

The issues of shipping noise and its effects on the marine environment have been addressed in detail by a consultant's report prepared for the Proponents[133]. While there are many uncertainties in such work[134], the present writer would agree with that report's conclusion that cetaceans would be able to hear SOEP supply vessels at distances of around 30 to 50 km. I do not, however, agree that their ability to distinguish those vessels from

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[131] *SOEP Response to Panel Information Request* 4.4.

[132] *SOEP Response to Panel Information Request* 2.13. Some SOEP activities are expected to require helicopter landings on Sable Island. In light of past experience on the Island and assuming a modicum of common sense on the part of all involved, it is the other "activities" that should be of concern – not the occasional helicopter landing.

[133] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* 21 p. The generation of underwater sound in general was recognized in the EIS as one pathway by which SOEP could impact the marine environment, and was discussed at some length in the EIA, though shipping noise does not appear in the Impact Assessment Matrix nor in the final summary of residual impacts: *SOEP Volume 3 – EIS* pp. 5-5, 5-10, 6-10 to 6-13, Tables 6.3-1, 7.7-1.

[134] For example, use of the sound source levels recorded for the supply ship *Canmar Supplier IV*, rather than those for the ice breaker *Robert Lemeur* [Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd* Fig. 3], would increase the expected intensities by about 10 dB, nearly doubling the estimated range at which the ships would be audible above background noise, using the same model of sound propagation and the same background noise levels.

background shipping noise is "problematic"[135] – the 30 to 50 km estimate is one of the distance at which a SOEP ship would be louder than background and hence incorporates something of the ability of an animal to distinguish one sound from others. Furthermore, although the Proponents do not say so, many fish would be equally capable of hearing these vessels, their ability being limited by the masking effect of ambient noise rather than by any lack of capability to detect sound at the intensities of concern[136]. Both fish and mammals would be aware of the movements of the SOEP ships even at considerable distances.

The more complicated question concerns the distance at which the sound of these ships would negatively affect the behaviour of the animals. The Proponents' consultant suggests that whales would only be affected at a range of about 4 km[137]. This writer would suggest that cetacean (and fish) behaviour is too complex for any such generalization. Both fish and mammals would use sound cues to avoid ships, though only at close range. Further off, they might be attracted, repelled or distracted from other activities – their exact response depending on the patterns of change in a sound (rapid increases in intensity tending to cause avoidance in fish) and likely their own recent experience and physiological state[138]. The acoustic environment for many kilometres around the SOEP sites will be affected by the project's shipping and it is to be expected that that will have some effect on animals living there. The degree of that effect remains unknown and, in terms of the Panel's decision, possibly irrelevant.

The very great distances at which supply vessels could be heard in the waters around Sable Island is not a function of any naturally-quiet conditions there but rather of the unusually good sound propagation conditions on the Scotian Shelf, resulting from a "channelling" of the sound waves between water layers[139]. Indeed, a supply vessel operating over the shallow depths around Sable Island might produce less sound energy in the Gully than a smaller vessel at a greater distance, steaming over deeper water to the north. Thus, this acoustic impact by SOEP should be seen as no more than one addition to a broad array of shipping noise generated throughout the eastern Scotian Shelf and entering the Sable area. Even locally, the expected number of offshore support and standby vessels present around Sable Island at any one time (outside of the SOEP construction period) would be less than a half dozen[140]. They would often be out-numbered by the offshore groundfish and scallop

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[135] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd* p. 15.
[136] Mitson, R,B, (ed.) (1995) Underwater noise of research vessels: Review and recommendations. *ICES Cooperative Research Report* 209.
[137] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd* p. 15.
[138] The literature on fish responses to sound is too extensive to review here. Some recent summaries can be found in: Schwarz, A.L. (1985) The behaviour of fishes in their acoustic environment. *Environmental Biology of Fish* 13: 3-15; Hawkins, A.D. (1993) Underwater sound and fish behaviour. *In:* T.J. Pitcher (ed.) *The Behaviour of Teleost Fishes.* (2nd edition) Johns Hopkins University Press, Baltimore: 114-151; Mitson, R,B, (ed.) (1995) Underwater noise of research vessels: Review and recommendations. *ICES Cooperative Research Report* 209.
[139] Zakarauskas, P., D.M.F. Chapman & P.R. Staal (1990) Underwater acoustic ambient noise levels on the eastern Canadian continental shelf. *Journal of the Acoustical Society of America* 87: 2064-2071. While the present writer would not wholeheartedly endorse the Proponents' comments on this topic (*SOEP Response to Intervenor Information Request* World Wildlife Fund Canada 5), their general thrust seems sound.
[140] *SOEP Responses to Scoping Process* p. 24.

draggers in their vicinity (ships that are little smaller and probably no quieter than an offshore supply vessel), plus many smaller fishing craft.

In short, the level of shipping noise on the Scotian Shelf, including the Sable area, is very high. It may even be high enough to be having a detrimental effect on marine life in the area. However, the increment to that noise level which the SOEP "fleet" would create would be small – except, of course, in the immediate vicinity of any one ship. Only to the extent that more general efforts to limit or reduce shipping activity in the area are justified, perhaps in connection with the proposed Marine Protected Area in the Sable Gully, would there any reason for concern over the acoustic effects of SOEP shipping specifically.

4.2.4 Aircraft Noise

In so far as aircraft noise is concerned, the transmission of sound from air to water is very inefficient and a passing helicopter should be effectively inaudible to any immersed animal not directly under its flight-path. Thus, the Proponents' contention that no significant impacts are anticipated from their planned use of helicopters[141] seems reasonable, at least in so far as the underwater environment is concerned. Surfaced seals and those hauled out on Sable Island could experience a significant auditory impact from SOEP aircraft, though the planned exclusion zone around the island should eliminate any meaningful effects.

4.2.5 Cumulative Impacts

It is in the nature of sound that a doubling of the energy emitted only increases the level received by 3 dB. Thus, additional sound inputs produce diminishing consequences and cumulative effects are strongly damped. Indeed, it is the high existing anthropogenic underwater sound levels around Sable Island that largely remove any concern associated with SOEP shipping. Aside from the noise produced, the project's shipping activity would have so little impact on the marine environment that its cumulative impacts need not be of concern.

Even the shipping associated with other offshore developments that might be encouraged by SOEP's progress would not be expected to have enough impacts to cause any significant effects – unless, perhaps, if those other developments extended deeper into the Gully area as they might if the *Primrose* field were developed.

4.3 Summary

The marine and aviation activities associated with SOEP should not have any effect on the marine environment worthy of concern. There is inevitably some small chance of marine mammals being injured or killed in collisions with ships but the exceptionally-vulnerable

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[141] *SOEP Response to Panel Information Request* 3.13. This support for the Proponents' conclusion is not intended as an endorsement of their use of the sound levels produced by a Tornado fighter aircraft at 100 ft altitude as a reference for judging impacts. Nor is it entirely fair to state, as that same response does, that the estimated sound level of a Sikorsky helicopter passing directly overhead at 1000 ft altitude (105 dB re 1 µPa) is approximately the same as the noise level generated on the Scotian Shelf by a 20 knot breeze. Zakarauskas, P., D.M.F. Chapman & P.R. Staal (1990 Underwater acoustic ambient noise levels on the eastern Canadian continental shelf. *Journal of the Acoustical Society of America* 87: 2064-2071) have estimated noise levels on the Scotian Shelf under such conditions at around 90 dB (a 30 times lower intensity) for frequencies of about 50 Hz – and much of that was shipping, not naturally-generated, noise.

right whales are not common in the Sable area, while SOEP's ships have little reason to approach the major concentrations of cetaceans known to exist in the Sable Gully. Direct interactions with seals are more likely but those animals seem well able to avoid dangerous contact with shipping. The noise of the ships would be widely heard, by fish as well as marine mammals, but would be but a small increment to the existing loud shipping noise on the Scotian Shelf.

A strict and extensive shipping exclusion zone covering the Sable Gully (preferably one stricter and more extensive than that suggested by the Proponents) would clearly serve to reduce further the risk of cetacean collisions in that area. Helicopter noise might to easily disturb wildlife on Sable Island itself and an exclusion zone covering all low-altitude flying (other than when landings are necessary) should be strictly applied. Indeed, as the Proponents have recognized, a strict code of practice covering all interactions with the Island is necessary.

These conclusions notwithstanding, the SOEP proposal is being reviewed in parallel with a slower and (to date) less formal review of a proposal to establish a Marine Protected Area (MPA) covering the Sable Gully[142]. The fate of that proposal and the nature of the protections, if any, that will later be applied within such an area are still unclear. If, however, the MPA was established with limitations on both shipping activity and shipping noise inside its boundaries, SOEP's shipping would have to be evaluated against different standards than those used here. Since it is the high level of existing shipping activity and noise that remove any reasonable prospect of a significant impact from SOEP shipping, those changed standards could reverse present conclusions. Indeed, the project's activities might prove to be the limiting factor in achieving noise reduction targets within a Sable Gully MPA. If the form of that MPA is clarified between the date of this report and that of the Panel's decision, this analysis of shipping activity should be re-visited.

[142] e.g. Anon. (1995) *Sea to Sea to Sea: Canada's National Marine Conservation Areas System Plan.* Parks Canada, Hull: pp. 76-77. ; Anon. (1995) Towards a conservation strategy for The Gully, near Sable Island, Nova Scotia. *Unpublished discussion paper, Canadian Wildlife Service*: 8p. ; Faucher, A. & H. Whitehead (1995) Importance of habitat protection for the northern bottlenose whale in The Gully, Nova Scotia. *In:* N.L. Shackell & J.H.M. Willison *Marine Protected Areas and Sustainable Fisheries.* SAMPAA, Wolfville: 99-102; Milewski, I. (1996) Fisheries considerations for a possible Marine Protected Area in The Gully. *Contract report to World Wildlife Fund – Canada*: 12p. There are a number of special features of the Sable Gully which have attracted this attention but particularly the presence there of one of only two major aggregations of northern bottlenose whales in western North Atlantic.

5. Drilling Discharges – Muds and Cuttings

5.1 Introduction

The drilling phase of SOEP would involve a great variety of discharges and emissions into the marine environment, along with ship and aircraft activities, most of which are dealt with in other Sections of this report. The predominant discharges during this phase, by volume and probably also by environmental impact, would however be the "cuttings", small chips of rock cut by the drill in forming the well, and the "muds" used in the drilling process to cool and lubricate the drill, carry the cuttings out of the hole and counter-balance the pressure of gas, when that is reached. These discharges, their fates and their environmental effects have been the most intensively studied (and argued) aspect of the offshore petroleum industry's environmental effect – it being generally thought that drill muds cause the greatest harm, other than that resulting from major accidents[143]. The resulting body of knowledge and the great concern of these discharges mean that this Section is rather more detailed than other parts of this report.

Scientists began studying the environmental effects of offshore drilling in the early 1970s and, by the mid-1980s, they had reached a general conclusion that, while harmful in the immediate vicinity of the wells, the effects were negligible even a short distance away. This conclusion was best summarized in a set of "Agreed Facts" prepared by the Paris Commission (which regulates certain types of pollutants in the North Sea) in 1985. This same view has been expounded by the SOEP Proponents in their 1996 submissions and subsequent documents[144] even though, in the interim, scientific understanding of these problems has under-gone a revolutionary change, leading to a general rejection of the "Agreed Facts". No new consensus has yet emerged as to the real environmental effects of offshore drilling but all indications are that, when such agreement does appear, it will show drilling as considerably more damaging than was once supposed.

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[143] DFO scientists have provided a great number of comments on the SOEP EIS relating to these kinds of discharges [Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* 40p]. Those not otherwise referred to in this Section include points on EIS Sections 1.3, 3.3.5.1, 5.2.1.3, 5.3.1.2, 6.3.1.1 & 7.2.1. The Proponents have not responded to any of the points made in that document concerning drill muds, except for providing a confirmation that they would not use "ABMs", by which they seem to mean that they would not use synthetic base oils in their drill muds.

[144] *SOEP Volume 3 – EIS* Sections 6.3.1.1 & 6.7.6; *SOEP – Responses to Scoping Process* Issue #14; *SOEP Response to Ecology Action Centre Information Request* 21; CORDaH (1997) Review of the environmental effects of the deposition of oil based drill cuttings and release of oil based muds. *Report prepared for Mobil Oil Canada Properties Ltd.* 14p.

The Proponents' initial claim (*SOEP Volume 3 – EIS*, p. 6-3), that "significant changes in biological communities" only occur within 500 m of sites with multiple wells was a gross misrepresentation of even the former conclusions of scientists studying these effects in the North Sea.

The Proponents' latest submission to the Panel [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pag.var.] does not follow the previous preference for pre-1990 conclusions and generally, though not invariably, seems to present current knowledge in a fair and balanced manner.

Because expert opinion is still so fluid and such recently-firm conclusions have been abandoned, leaving serious errors in scientific literature published less than a decade ago, it is necessary to describe the progress of this shift in specialist understanding and the existing limitations on current knowledge before proceeding to a discussion of the likely effects of SOEP discharges of drill muds and cuttings. This is in no sense intended as a thorough review of the relevant scientific literature but rather a focused account, designed to set scientific understanding of the effects of SOEP in its context.

This account relies heavily on experience in the North Sea, where there has now been more than 30 years of offshore drilling and 25 of oil production[145]. Other sea areas either have very different environments, which are likely to respond quite differently to the stresses introduced by offshore petroleum activities, or else have seen little serious study of the environmental effects of such stresses. The former would include the Gulf of Mexico, which is much warmer than the northwest Atlantic and has an ecosystem adapted to high levels of organic input from the Mississippi[146], and the Beaufort Sea, which is much colder than the Scotian Shelf. The latter group would include the oil fields off California and the natural gas fields in Bass Strait, Australia, each of which has a marine ecosystem generally comparable to that around Sable Island but neither of which has been much studied from an environmental effects perspective[147]. Aside from the limited amount of information from (mostly exploratory) drilling in the northwest Atlantic, only the North Sea offers much documented experience relevant to the SOEP proposal[148].

This account does combine information from both oil and natural gas wells. Once into the production phase, the environmental effects of oil and gas operations may be quite different. However, while the wells are being drilled (and with the possible exception of the likelihood and severity of a blowout) the nature of the hydrocarbon that will eventually be drawn through them is unlikely to be of much significance[149]. This account also

[145] de Groot, S.J. (1996) Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. *ICES Journal of Marine Science* 53: 1045-1050.

[146] The effects of the offshore petroleum industry on the Gulf of Mexico environment have recently been summarised in a set of papers on the Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX). They appear to be much less severe than those in the North Sea (or probably the Scotian Shelf) environment: Kennicutt M.C., R.H. Green, P. Montagna & P.F. Roscigno (1996) Gulf of Mexico Offshore Operations Monitoring Experiment (GOOMEX), Phase I: Sublethal responses to contaminant exposure – introduction and overview. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2540-2553.

[147] But see: Brewer G.D., J.L. Hyland & D.D. Hardin (1991) Effects of oil drilling on deepwater reefs offshore California. *American Fisheries Society Symposium* 11: 26-38.

[148] Over 7,000 oil and gas wells (counting exploratory, appraisal and development wells) have been drilled in the North Sea, well over 200 platforms and other installations have been constructed and some 10,000 km of pipeline laid [de Groot, S.J. (1996) Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. *ICES Journal of Marine Science* 53: 1045-1050]. The northwest Atlantic has seen no comparable development. A few hundred exploratory wells have been drilled in Canadian waters, with eight others being drilled on the U.S. side of Georges Bank in the early 1980s. The only development drilling, however, has been at the small *Cohasset* and *Panuke* fields ("COPAN") , near Sable Island which produced its first oil in 1992. At the time of writing, the platform for the very much larger *Hibernia* project was under-going final assembly, early for installation on Grand Bank later in 1997.

[149] Most studies of offshore environmental effects have concentrated on oil exploration and production. What little evidence there is does, however, suggest that the impacts of the drilling phase are the same with oil and gas wells. See, for example, the studies around the *Vulcan* and K12a gas platforms in the southern North Sea: Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee,

combines information from both shallow and tide-swept areas, such as the southern North Sea, Georges Bank and Sable Island Bank itself, with that from deeper, lower-energy environments, such as the northern North Sea. The environmental effects of drilling are actually rather different in these different areas[150] and the information from the low-energy ones may not be directly relevant to the shallower waters of Sable Island Bank. Much of the available research has been done in the northern North Sea, however, providing knowledge not available anywhere else, while the effects of drilling in such areas may help indicate likely differences among the SOEP sites, contrasting the deeper *Alma* and *Glenelg* with the shallower *Venture* and *Thebaud*. It is, nevertheless, necessary to remember that the extremes of environmental effects observed in the Norwegian sector of the North Sea might not be repeated off Sable Island, even with the same intensity of drilling.

Following this account of present scientific understanding, this Section continues by outlining the nature of the various discharges under discussion (see Section 5.4) and then examines both their fates and their effects on the marine environment (see Section 5.5). That is followed by some attempt to bound the range of effects that the SOEP discharges might cause. As elsewhere in this report, those final remarks are intended as general guidance only and not as a substitute for the adequate EIA which the SOEP Proponents have failed to provide.

5.2 A Revolution in Understanding

Offshore drilling began gradually in the Gulf of Mexico in the mid-twentieth century. The petroleum industry then moved on to other offshore areas, beginning around 1960. The first well in the North Sea was drilled in the Netherlands sector in 1963, while gas was struck in the United Kingdom sector in 1965 and oil in Danish waters in 1967, which was also the first year of gas production from the North Sea[151]. In that same year, however, the tanker *Torrey Canyon* went aground off the English coast, creating the worst oil spill the world had yet seen. Although the tanker had no connection with the offshore petroleum industry, this conjunction of events, coupled with the emergence of strong environmental consciousness at that time, drew close public scrutiny onto the developments in the North Sea[152]. A corresponding scientific effort thus arose around the offshore petroleum industry.

W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89; Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.

[150] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.

[151] Oil production from the North Sea started with the Norwegian *Ekofisk* field, in 1971: de Groot, S.J. (1996) Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. *ICES Journal of Marine Science* 53: 1045-1050.

[152] Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89; Jones, A.M. (1989) The environmental impact of North Sea oil. *Science Progress, Oxford* 73: 457-468; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea.

At first, it was assumed that the primary environmental problem was the release of hydrocarbons into the sea and also that the largest quantity released would be in the produced water. However, experience soon showed a more immediate concern: the wells were being drilled with oil-based drilling muds ("OBMs" – see Section 0) prepared with highly-toxic diesel – that being the most readily-available oil. Despite routine cleaning, the drill cuttings were being deposited on the seabed still coated with the OBM[153]. The high toxicity of this diesel and its tendency to be concentrated among the cuttings on the seabed under each drilling rig, instead of dispersed and diluted throughout the water column as oil in the produced water was, made the discharge of OBM-contaminated cuttings particularly worrying. Indeed, the effects of this OBM on the seabed provided the only immediately obvious environmental impact of the offshore petroleum industry, smothering the bottom under the rigs and raising sediment hydrocarbon concentrations to extreme levels. Since the cuttings largely lay where they settled on the seabed, however, their impacts seemed to be confined to a zone some hundreds of metres in radius around each drill site. By the mid-1970s, therefore, studies of the ecological effects of the industry had primarily become research into the effects of OBM cuttings on seabed habitats in the immediate vicinity of offshore drill rigs[154].

This was, no doubt, a comfortable and convenient decision for all concerned. The public could not reasonably object to the oil industry disrupting the seabed immediately under its own platforms and the emphasis on oiled cuttings drew attention away from any potential wide-area impacts that could affect broader ecosystem components. Governments could have their cake while eating it; enjoying the economic benefits of the offshore industry while trusting the absence of scientific comment about distant impacts as a sign that the wider marine environment was safe. The regulatory authorities were saved from difficult decisions – so long as the areas impacted were tiny, nobody needed to care whether those impacts were "significant", what "significance" means, nor whose interests should be considered in making such judgements. For their part, the scientists concerned had a tractable problem, offering questions that could be answered. The cuttings introduced a known type of toxic oil to a fixed point on the seabed in concentrations high enough to kill many organisms, while the presence of the oil could be monitored by taking sediment samples at various distances around the cuttings discharge site and the toxicity of the concentrations found could be examined in laboratory experiments. Broader impacts that would inevitably be masked and complicated by natural variations and the effects of other human activity (particularly the release of land-based pollutants) could be ignored, along with all of the conceptual and methodological difficulties that they would have introduced. This is not to say that anyone deliberately ignored evidence of wide-area impacts but simply

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ICES Journal of Marine Science 49: 45-53; de Groot, S.J. (1996) Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. *ICES Journal of Marine Science* 53: 1045-1050.

[153] An estimated 29,000 tons of oil was released to the North Sea by the offshore petroleum industry in 1986 alone and, of that 90%, was from OBM-contaminated cuttings. Yet 1986 saw many fewer wells drilled than either 1984 or 1985: Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.

[154] Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.

that the initial evidence that all detectable impacts of offshore drilling occurred on the seabed close to the rigs was particularly acceptable to the petroleum industry, to governments and to those scientists working on the problem.

Study of the effects of OBM-contaminated cuttings was tractable but it still wasn't easy. Well into the 1980s, most of the research seems to have been methodological – a generation of oil pollution specialists carved out a set of techniques that they could agree, among themselves, were appropriate for answering the questions that they thought they faced. Those techniques look unbelievably crude to a sceptical, modern eye but, twenty years ago, they no doubt promised answers while also straining contemporary technical capabilities and available budgets. And since the questions that these methods could be applied to did not threaten economic development, nobody outside the select group of specialist scientists had much incentive to question what was being done.

In retrospect, however, a serious problem was developing. The specialists were, of course, university-trained scientists. Looking over their reports, it often seems that they adopted the usual orientation of "pure" science in which the objective is to find the correct answer to any question, rather than the proper orientation of applied science, which is to find the best available answer to the relevant question. This can be seen in many subtle ways, such as an emphasis on measurable phenomena, without regard to their significance to the wider world, and on a preference for standardized techniques and indices (such as measures of diversity) rather than an attempt to understand ecosystem function in sufficient detail to be able to recognize pollution-induced perturbations. Also following university-based precedents, these specialists emphasized a classically reductionist approach, looking, for example, at the distribution of diesel at concentrations that could be shown, in the laboratory, to be acutely lethal to various species. As late as 1993, GESAMP[155] prepared a report on the impact of oil on the marine environment[156], rather than on the impacts of oil development, whether caused by released hydrocarbon or the noise of passing ships, for example. This is a natural perspective for a specialist in the ecotoxicology of hydrocarbons in the marine environment but not the most useful one for a decision-maker seeking scientific information relevant to the regulation of an industrial sector. Yet public policy decisions should be based on overall (or "holistic") concerns – what effect the development of offshore oil reserves has on the economic value of the marine ecosystem, for example, rather than on how close to a well site one particular species of burrowing worm can survive. Finally, the North Sea studies seem to have adopted the onus conventional in "pure" science and commonly known as "Occam's Razor" – phenomena were assumed not to occur unless and until positive evidence was gathered proving their occurrence with reasonable certainty (often meaning proof of statistical "significance" with $\alpha = 0.05$). That is, of course, an appropriate basis for scientific research but in environmental management it is often necessary to follow what is now termed the "Precautionary Principle" – a matter of avoiding potential harm unless and until it can be shown not to occur[157]. Since proof of

[155] GESAMP is formally the Joint Group of Experts on the Scientific Aspects of Marine Pollution. It is sponsored by several UN bodies, including IMO (International Maritime Organization), FAO, UNESCO, WMO (World Meteorological Organization), WHO, IAEA (International Atomic Energy Agency), and UNEP.

[156] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.

[157] The precise nature of the proper onus of proof in different kinds of scientific work still produces heated arguments within the environmental science community. See, for example: Gray, J.S. (1990) Statistics and the precautionary principle. *Marine Pollution Bulletin* 21: 174-176; Johnston, P. & M. Simmonds (1990) Precautionary principle. *Marine Pollution Bulletin* 21: 402; Josefson, A.B. (1990) *Marine Pollution*

the non-occurrence of a phenomenon usually requires an utterly different experimental design from prove of its occurrence, much of the environmental research around oil platforms has tended towards irrelevancy – being designed to answer questions that were never asked by environmental managers or the public, it has been unable to provide those groups with the scientific information that they need.

By the mid-1980s, the basic picture had been set[158]. The only significant impacts of the offshore petroleum industry were said to be a result of the introduction of hydrocarbons to the seabed, primarily as OBM residues on cuttings. Those impacts were very severe immediately under the platforms but hydrocarbon concentrations declined to levels indistinguishable from "background" with a few kilometres, no noteworthy environmental effects were expected more than one or two kilometres from even a multiple well site. This general conclusion was summarized in 1985 by a working group of the Paris Commission in the form of its "Agreed Facts", which included:

- Cuttings from OBM and WBM drilling can have an adverse effect on the benthic community, the effects of OBM cuttings being substantially greater, at least when multiple wells are drilled,
- Beneath the platform, these effects are mainly due to physical burial of the natural seabed,
- Major deleterious effects are confined with 500 m of the platform, where recovery is likely to be slow,
- Lesser biological effects, detected as changed community parameters, extend to 1000 or, with stronger currents and more drilling, 2000 m from a platform, and
- Elevated hydrocarbon levels can extend as much as 4 km down-current[159].

Bulletin 21: 598; Lawrence, J. & D. Taylor (1990) *Marine Pollution Bulletin* 21: 598-599; Gray, J.S. (1990) *Marine Pollution Bulletin* 21: 599-600; Peterman, R.M. & M. M'Gonigle (1992) Statistical power analysis and the precautionary principle. *Marine Pollution Bulletin* 24: 231-234; Buhl-Mortensen, L. (1996) Type-II statistical errors in environmental science and the precautionary principle. *Marine Pollution Bulletin* 32: 528-531; Gray, J.S. (1996) Environmental science and a precautionary approach revisited. *Marine Pollution Bulletin* 32: 532-534.

[158] This picture is reflected in many research reports, including: Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89; Davies, J.M., R. Hardy & A.D. McIntyre (1981) Environmental effects of North Sea oil operations. *Marine Pollution Bulletin* 12: 412-416; Hartley, J.P. (1982) Methods for monitoring offshore macrobenthos. *Marine Pollution Bulletin* 13: 150-154; Mair, J.McD., I. Matheson & J.F. Appelbee (1987) Offshore macrobenthic recovery in the Murchison Field following the termination of drill-cuttings discharges. *Marine Pollution Bulletin* 18: 628-634; Jones, A.M. (1989) The environmental impact of North Sea oil. *Science Progress, Oxford* 73: 457-468; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53.

[159] Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.

Under this view of the impacts of offshore drilling, the area subject to even subtle biological effects was tiny – only 0.13% of the United Kingdom sector of the North Sea, for example[160]. If it had been correct, this would have meant that the effects of the offshore petroleum industry were almost inevitably negligible, simply because they could not touch enough of the ocean to matter.

However, this tidy and comfortable conclusion began to fall apart almost as soon as it was clearly stated. When the Paris Commissions' then-new "Agreed Facts" were discussed at a conference in 1988, the proceedings editor noted in his concluding summary that they might yet change and also touched on a controversy that had just been sparked at his meeting by the results of environmental monitoring around Norwegian oil platforms[161].

Norway had carried out a comprehensive environmental monitoring program around its offshore installations since 1973[162]. Ecological analyses of the resulting data had been confined to the usual species-number and diversity indices[163] and had found effects only to 1.5 km or so from the wells, aside from a few "indicator" species which showed responses out to perhaps 3 km – all of which accorded with the general consensus as it then was. In 1986[164], however, some of the data were re-examined and re-analyzed, showing hydrocarbon contamination as much as 12 km from the *Statfjord B* platform[165]. Later, some of these same monitoring data were analyzed using multivariate statistical methods to look at changes in species composition of the benthic communities (rather than simply their diversity), which produced evidence of ecological effects as much as 5 km from the *Ekofisk* site[166], a limit which has since been raised to 6 km from the *Valhall* platform[167]. Since these results meant that the impacted area was greater than had been predicted in the relevant EIAs, the Government of Norway acted swiftly to tighten regulations, ultimately banning all offshore discharge of cuttings from OBM drilling, with

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160 GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 117.
161 Ray, J.P. (1989) Offshore drilling waste issues. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 849-859.
162 Widespread environmental effects monitoring around platforms in the United Kingdom sector did not begin until 1983: Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.
163 Measures so crude that theoretical quantitative ecologists moved away from them in the mid-1970s.
164 Date as given by: Daan, R., H. van het Groenewoud, S.A. de Jong & M. Mulder (1992) Physico-chemical and biological features of a drilling site in the North Sea, 1 year after discharges of oil-contaminated drill cuttings. *Marine Ecology Progress Series* 91: 37-45.
165 Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989) Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117.
166 Warwick, R.M. & K.R. Clarke (1991) A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244.
167 Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.

effect from 1993[168]. The German, Danish and Netherlands governments have also banned such discharges[169].

Meanwhile, other decisive evidence was being gathered in the northwest Atlantic. Following a number of ineffective attempts at Environmental Effects Monitoring ("EEM") around various offshore installations in U.S. waters[170], a much more appropriate EEM program was designed for the exploratory drilling on Georges Bank in 1981-82. It included monitoring of barium (a tracer of drilling mud, which contains a high percentage of barite) at a wide array of stations. In the event, the barium concentration in fine sediment (sieved from samples of seabed sediments) at a monitoring station 35 km east of the drill sites doubled during the period of drilling. The same index at a station 65 km to the westward of the wells (down the residual current) rose by as much as six times. In the opinion of the scientists involved, the likely reason that barium increases were not found at still more distant sites was that the natural sediments at the sampling points chosen were muddy, diluting any barium-rich mud from the drilling to undetectable levels[171].

Then, in the early 1990s, a research team from the Bedford Institute of Oceanography undertook some field studies around the COPAN platform on Sable Island Bank. Having noted the crudity of the conceptual models being used in designing environmental impact studies around offshore installations, this team had developed advanced sampling gear that would allow study of more complex environmental mechanisms. In 1993, following seven months of drilling, this equipment was deployed on Sable Island Bank and showed that the seabed around the rig was covered with light flocs, composed of a mixture of biotic material and drilling wastes. Substantial amounts of this material were found as far as 2 km from the platform, with some at more distant stations –even the most distant one sampled, 15 km from the platform– though natural flocs have since been seen on Sable Island Bank and those observed beyond 2 km from the COPAN platform may not have been drilling-related[172].

Meanwhile, back in the North Sea's East Shetland Basin, routine surveys had been conducted of sediments at stations 5 and 10 km from the nearest platform. In 1980, these locations had sediment hydrocarbon concentrations in the range of about 2 to 90 ppm. By 1988, this had risen to about 80 to 900 ppm[173]. In a number of studies, levels above

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[168] Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.

[169] Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.

[170] Carney, R.S. (1987) A review of study designs for the detection of long-term environmental effects of offshore petroleum activities. *In:* D.F. Boesch & N.N. Rabalais (*eds.*) *Long-term Environmental Effects of Offshore Oil and Gas Development.* Elsevier Applied Science, London: 651-696.

[171] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

[172] Muschenheim, D.K. & T.G. Milligan (1996) Flocculation and accumulation of fine drilling waste particulates on the Scotian Shelf (Canada). *Marine Pollution Bulletin* 32: 740-745; Muschenheim, D.K., T.G. Milligan & D.C. Gordon (1995) New technology and suggested methodologies for monitoring particulate wastes discharged from offshore oil and gas drilling platforms and their effects on the benthic boundary layer environment. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2049: 55p; T.G. Milligan, Department of Fisheries and Oceans, Bedford Institute of Oceanography, *pers.comm.*

[173] Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53. Kingston's conclusions have apparently been challenged in an

50 ppm of total hydrocarbon in sediments have proven capable of reducing the diversity of the benthos, while some sensitive species appear to be affected by concentrations below 10 ppm[174], so the observations in the East Shetland Basin are by no means insignificant. Interestingly, the composition of this background hydrocarbon shows that it is not derived from OBM and may have come from produced water, from flaring inputs or even from shipping discharges[175], though there is little reason to suppose an increase in the last of these possible sources through the 1980s. Thus, not only was this oil found several times further from offshore platforms than accepted wisdom would have suggested but it was derived from a source that had been all but ignored by oil pollution specialists.

A number of important conclusions can be drawn from this brief tale:

- The tidy summary of the environmental impacts of the offshore petroleum industry that was developed from 1975 to 1985, and which was summarized in the Paris Commission's "Agreed Facts", has since been discredited. The reasoning on which it was based must be set aside, along with the many published conclusions associated with it, and the offshore petroleum industry's real impacts re-evaluated.
- Much of the research conducted over the past 25 years on these impacts will be of limited use in this re-evaluation. Being predicated on an assumption that the effects could not extend more than a couple of kilometres from a discharge point, many studies only sampled areas well within the zone now known to be

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unpublished report prepared for the United Kingdom Offshore Operators Association [Cranmer, G.J. (1994) UKOOA review of North Sea background sediment hydrocarbon data. *Metocean PLC report for UKOOA* 58p. — cited in: CORDaH (1996) Review of the environmental effects of the deposition of oil based drill cuttings and release of oil based muds. *Report prepared for Mobil Oil Canada Properties Ltd.*: p. 6]. This report has not been made available for peer review, however. Indeed, a direct approach to UKOOA produced a reply to the effect that copies will not be released to non-members of that Association (I. Milewski, World Wildlife Fund Canada, *pers.comm.*). Until it is made available for examination by the Panel and the Intervenors, its claimed conclusions cannot be given equal credence with a published study, though they are a reminder that even peer-reviewed conclusions can be wrong.

It is indicative of the speed of change in scientific understanding of the effects of offshore production that, as late as 1988, Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989. The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89) could report that only 0.55% of the U.K. sector of the North Sea was detectably contaminated by offshore-related hydrocarbons, while noting that the background contamination in the East Shetland Basin was "being investigated" – investigations that were already indicating that their estimates were two orders of magnitude too low. GESAMP (1993. Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.) repeated Davies *et al.*'s quantitative conclusion, despite having access to Kingston's work, and it is only in the last two or three years that the errors in the previous conclusions have been widely realized.

[174] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989) Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117.

[175] Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53; GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.

potentially affected. Without reference data, gathered either before the impacts started or far enough from the platforms to be beyond their influence, all that such studies can do is to compare the effects of severe and relatively-mild impacts – something that is of limited value to decision-makers.

- It is no longer possible to ignore questions about the significance of various impacts. If no effect occurs beyond 1500 m from any platform, there may be little reason to worry whether the effects inside that range are serious. Now that it has been shown that drilling eight wells spread detectable levels of barite over much of Georges Bank, the COPAN drilling near Sable Island spread flocculant material some kilometres from the source, Norwegian oil production has affected benthic communities over some 100 km^2 around major platforms and that background sediment hydrocarbon levels seem to be rising in the United Kingdom sector of the North Sea, the relevance of such impacts can no longer be ignored. It would be as wrong, now, to suppose that all detectable pollutants and environmental changes are necessarily unacceptable as it has been in the past to suppose that whatever was not measured could not hurt and hence difficult questions must be faced anew.
- Along with this radical change in the area known to be affected by drilling has come the realization that a variety of pollutant inputs from the offshore industry, in addition to simply OBM-contaminated cuttings, can have impacts on the marine environment and can do so through more complex pathways than were commonly envisioned in the 1980s. These complexities can no longer be ignored either.

Unfortunately, these conclusions were not drawn by the one quasi-official summary of the environmental effects of the offshore petroleum industry that has been prepared since the Norwegian monitoring results changed specialist opinion. That document[176], prepared in 1990-92 by GESAMP's working group on the impacts of oil from offshore petroleum operations, was produced (not without apparently intense debate – which spilt over into an editorial in *Marine Pollution Bulletin*[177]) when the new information was still being digested. In retrospect, the GESAMP report, which should be the authoritative statement of current scientific understanding, is instead an intermediate step in a transition from the Paris Commission's "Agreed Facts" to a broader knowledge of the impacts of offshore drilling[178]. That such a document published in 1993 can seem so dated by 1997 indicates the speed of change in specialist understanding in this field and the danger of taking any conclusions, even the most recent, at face value. Indeed, it is now necessary to return to primary observational evidence and thence to construct a new summary of the environmental effects of the offshore petroleum industry, as a basis for estimating the effects that SOEP would have.

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[176] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.

[177] Gray, J.S. (1991) Anthropocentric or ecocentric? *Marine Pollution Bulletin* 22: 529. GESAMP's 1990 *State of the Marine Environment* review has attracted equally sharp criticism :Taylor, P. (1993) The State of the Marine Environment: A critique of the work and role of the Joint Group of Experts on Scientific Aspects of Marine Pollution (GESAMP). *Marine Pollution Bulletin* 26: 120-127.

[178] This adjustment in understanding may seem slow to an outside observer but, for such a profound change in scientific understanding, it has actually proceeded quite quickly. Scientists are little better than anyone else at abandoning long-held ideas, even when the evidence requiring such a change is strong. In the present case, the breakdown of the specialists' accepted conclusions began in the mid-1980s and the consequences are still being worked out a decade later.

5.3 Detecting Environmental Effects in the Sea

Before doing so, it is necessary to consider some more issues concerning the nature of an "environmental effect", its significance and the evidence needed to say whether or not it occurs.

5.3.1 Significance and Detectability

There is an unfortunate tendency in the oil-pollution literature to assume that an effect that cannot be detected is not significant[179]. This idea has an obvious appeal since, in everyday experience, if something is of so little consequence that we do not know that it is happening to us, it is hard to accept that it matters. In reality, that logic is entirely fallacious – as daily exposure to carcinogens or radioactive materials would demonstrate.

In the ocean, our ability to measure change is so weak that gross damage could be done to resource productivity without anybody being aware of the fact. If, for example, the groundfish of the eastern Scotian Shelf suffered a one-time 25% or even 50% die-off, it is most unlikely that anyone would ever know for certain that that had happened since we have almost no ability to even estimate average rates of non-fishing mortality, let alone to measure their inter-annual changes. Sustained annual "natural" (i.e. non-fishing) death rates in the NAFO Divisions 4TVW haddock management unit could rise from about 20% (their likely normal level) to well over 30% and yet the possibility of that change would only be argued over years later when the resulting errors in management caused another collapse of the fisheries[180]. Similarly, year-to-year variations in the numbers of young recruits to each fish stock are so large that a one-time loss of 90% or more of the young-of-the-year would only be noticed as another "naturally" poor year. Even a sustained 50% reduction in recruitment would not be clearly recognizable for a decade or more, no matter how precisely the numbers of recites could be documented. Reduction of growth rates of the fish would be rather more detectable than these changes in recruitment and death rates, though 10% changes might still pass unnoticed and, even if detected, it would be all but impossible to establish the cause of the decline.

Since Nova Scotia's fisheries have annual landed values around half a billion dollars and overall values to the Provincial economy that are several times higher still, it would be possible for some of these changes to take a billion or so dollars out of the Provincial economy annually. Such an effect would most certainly be "significant", in a social and economic sense, despite remaining undetectable at the resource level.

Conversely, some chemicals may be fully detectable at levels far below those at which they could have any significant impact on the environment. The detection of barium (presumably in barite) on Georges Bank, 65 km down-stream of the exploratory wells of the early 1980s[181] may be such an example. Since there is so little mud in the natural sediments in

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[179] cf. Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society* Symposium 11: 1-8. This error can even be seen occasionally in GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.

[180] Indeed, exactly this has happened with respect to the likely increase in death rates caused by the expanding seal herd on Sable Island: e.g. Angel, J.R., D.L. Burke, R.N. O'Boyle, F.G. Peacock, M. Sinclair & K.C.T. Zwanenburg (1994) Report of the workshop on Scotia-Fundy groundfish management from 1977 to 1993. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1979: 1-14.

[181] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

that area, it is technically possible to separate a barite-enriched mud fraction from a sediment sample and then to establish its high barium content. That does not necessarily indicate that the overall concentration of barite, a material that is known to have very low toxicity anyway[182], was anything more than a tiny fraction of that required to influence the benthos. (Nor, of course, does it indicate the reverse – environmental effects need a different form of survey than is required for the detection of barite.)

5.3.2 Spatial and Temporal Complexity

The natural world is intricately complex, with every square metre of seabed being different from every other and each square millimetre tending to be more similar to the others within its own square metre than those outside – but yet not identical to them. Nor is this spatial complexity constant through time. Rather the whole pattern is constantly changing over cycles (diel, tidal, annual etc.) and with less-regular changes (e.g. storm events). Not only do these temporal variations change the characteristics of each square metre of seabed but they also change each one relative to each other; one that had coarser sediments than its neighbour changing to finer ones as a result of storm-induced transport, perhaps. If this makes the seabed complex, the water column is even more variable. Not only does it have a third dimension but it is subject to constant turbulence over many spatial scales.

These sorts of complexities make detecting any but the most extreme environmental impacts extraordinarily difficult. Change through time at a point in space is to be expected, without any anthropogenic impacts, and thus cannot be firmly ascribed to environmental effects unless the cause is beyond reasonable doubt (as when the effect is the presence of oil in sediments and the impact is the nearby release of oil with the same composition). Change, through time, in the difference in some parameter measured at two points is hardly a better guide. There are statistical techniques that circumvent these problems[183] but they do not seem to have yet been applied in studies of the environmental effects of the offshore petroleum industry. It follows that all such studies to date have only been able to detect gross effects – where the particular human impact in question swamps all other influences on the fauna, flora and habitats of a study area. One may reasonably assume that, although not yet detected, subtler effects do occur in response to lesser impacts – which means at greater distances from a point source of impact, such as an offshore natural gas production platform. Whatever the current maximum extent of detected environmental effect around such a platform, the likely (but unproven) extent of actual impacts is greater and perhaps much greater.

Spatial and temporal complexity do more than complicate the detection of environmental effects. They impose an added complexity on those effects. Should a seabed area contain muddy patches amongst sandier areas, for example, and a specific pollutant tend to be deposited in mud, it will impact on those species that inhabit the muddy patches but not on others that they live amongst. If the more susceptible species prefer coarser sediments, they may be safe from levels of contamination that, in laboratory tests, would be deleterious – though if the susceptible species inhabited the mud, average concentrations of pollutants that would be non-toxic could prove fatal as the pollutants concentrated in the muddy

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[182] Neff, J.M., R.J. Breteler & R.S. Carr (1989) Bioaccumulation, food chain transfer, and biological effects of barium and chromium from drilling muds by flounder, *Pseudopleuronectes americanus*, and lobster, *Homarus americanus*. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 439-459.

[183] e.g. Underwood, A.J. (1992) Beyond BACI: The detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology.* 161: 145-178.

patches. Much the same could be said of plankton blooms that occur in "patches in time" amongst relatively barren seasons, as well as patches in space.

Once again, the monitoring surveys previously conducted around offshore platforms have been inadequate to handle such complexities, being designed only to look for smooth gradients in levels of effect, heading away from the platform sites. Such monitoring might over- or under-emphasize the extent of affected patchy areas, depending on the analytical methods used and on whether the outer-most sampling stations chanced to fall on relatively-affected or relatively-unaffected patches.

Any attempt to predict, measure, interpret or understand the environmental effects of anthropogenic impacts must take all of these complexities into account, since it is effects on the environment, in all its complexity, that are of concern. When building predictions of the effects to be expected from SOEP, interpreting such scientific knowledge as exists in terms of its relevance to the Sable Island area, these complexities must be very much in mind.

5.4 Mud and Cuttings Discharges

In this section, the natures of the principal drilling discharges are described, including their initial fates on release into the marine environment. Their ultimate fates and their effects on the environment are addressed in Section 5.5. Both general offshore drilling issues and such specific information on SOEP as its Proponents have made available are considered.

5.4.1 Classes of Drill Muds

Drill muds are complex mixtures of a very large number of substances, with the exact composition being continuously varied to meet the technical demands of the drilling. Each is based on a carrier fluid, which can be either water (giving a "Water Based Mud" or "WBM") or oil ("Oil Based Mud", "OBM"), the former being environmentally preferable for offshore drilling but the latter being high desirable (if not essential) when coping with certain drilling problems. OBMs are particularly necessary for directional drilling, in which the well diverges from the vertical, allowing dispersed points in the hydrocarbon-bearing strata to be tapped from a single platform site.

The SOEP Proponents plan to use both WBM and OBM, the former for the upper parts of each well and the latter for the lower ones. They anticipate that the first 25% of drilling time at each well would use WBM and the remainder OBM, though the volume of WBM cuttings that would be released is expected to exceed that from OBM drilling[184].

5.4.2 Water Based Muds

Suspended and dissolved in the water, WBMs contain many chemicals in everything from trace amounts to bulk quantities. A typical North Sea WBM, in so far as any such thing exists among the wide variety of formulations, might contain[185]:

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[184] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pp. 1-2 & 3-7, Tables 3.8 & 3.9. An earlier estimate was that WBM would be used for around 40% of the drilling time on each well: *SOEP Volume 3 – EIS*, p. 3-57.

[185] List based on information in GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, pp. 106-108.

- Barite (barium sulphate), up to 1.4 Kg.l^{-1}
- Bentonite (a volcanic clay, largely composed of montmorillonite and beidellite – both hydrous aluminium silicates), up to 140 g.l^{-1}
- Caustic soda
- Soda ash
- Sodium bicarbonate
- Inorganic salts
- Surfactants and detergents
- Oil lubricants
- Biocides
- Speciality additives: viscosifiers, dispersants, shale inhibitors, oxygen scavengers, corrosion inhibitors etc.

The Proponents have presented a very different WBM composition which they have also used in estimating the environmental effects of their drilling, though it is not clear whether there is a specific intention to use such a mud. Their listing[186], converted to amounts per litre, includes:

- Potassium chloride 40-60 g.l^{-1}
- Bentonite 23-40 g.l^{-1}
- Lube 100 (low-toxicity lubricant) ≈30 g. l^{-1}
- Sodium hydroxide 1.4-2.85 g.l^{-1}
- Polyplus (fluid loss polymer) 1.45 g.l^{-1}
- Xanthan gum natural polymer (“ECD”) 1.4 g.l^{-1}
- Soda ash 0.7 g.l^{-1}

This would be a very low-density drill mud, not much denser than seawater[187], and so only suitable where well pressures were very low.

Besides their intended constituents, drill muds, both WBMs and OBMs, often contain high levels of heavy metal contamination[188]. WBMs, despite their water base, also often contain

[186] *SOEP Volume 3 – EIS*, Table 3.3-12; MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Table 3.4. The SOEP Proponents have not provided an adequate account of the various drill mud additives that they would or might use, nor of the effects that those might have on the marine environment [cf. Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 3.3.2.2]. Some of the substances that might be added, such as lignosulphonates, are potentially environmentally damaging and must be considered in an EIA if there is any chance that they might be used in drilling.

[187] Specific gravity 1.04 to 1.08, whereas seawater specific gravities are around 1.025, depending on temperature and salinity.

[188] Gillam, A.H. (1987) Chemical monitoring of North Sea oil installations. *Oceans ‘87*, IEEE, New York: 1585; GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, p. 107.

appreciable amounts of oil: under some circumstances, it is necessary to add a "pill" of oil to the circulating WBM and this is usually left in the mud, gradually being dispersed through it and ultimately discharged with it[189].

All drill muds circulate in the well when in use and they are routinely, re-conditioned and re-used – the cuttings being extracted from the circulation as the drilling proceeds. In time, however, the muds become unsuitable for further use and have to be replaced. The universal practice with WBMs offshore seems to be the discharge, direct to the sea, of all such waste mud, either as a more-or-less steady stream or as a short, high-volume "bulk discharge". Inevitably, some WBM is also discharged with the cuttings produced by the drilling (see Section 5.4.4). Aside from such ancillary losses, the SOEP Proponents have stated that they expect to discharge all of the WBM from each well (around 350 m^3) once, at the time of change-over to OBM drilling, with flow rates of over 100 m^3 of WBM per hour for one to three hours per well[190].

The overall quantities of WBM discharged can be high. While the water naturally disperses into the ocean, the other constituents represent substantial contamination. The eight exploratory wells drilled with WBM on Georges Bank in 1981-2, for example, resulted in some 4000 tons of barite and 1500 tons of bentonite clay being discharged[191]. Drilling SOEP's 28 wells is expected to result in more than 8,000 tons of barite and 4,000 of bentonite being added to the sediments of Sable Island Bank[192]. (If the Proponents used their declared mud compositions, however, all of the barite would be in OBM and thus not freely released to the environment.) Very much smaller, though still considerable, quantities of the other WBM components would also be released, some of them being notably toxic[193]. These quantities would, however, be released over a total of seven drilling seasons, spread from 1997 to 2007, under the Proponents' announced plans[194], and at a total of six or seven sites, stretching from *Venture* to *Alma.*.

5.4.3 Oil Based Muds

The OBMs of the early 1970s used diesel as the base oil, since that was readily available. Diesel, however, contains various additives that are highly toxic and the use of diesel-based

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[189] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, p. 112.

[190] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 1-2. The Proponents have also stated that there would be continuous discharge of WBM, in addition to "batch dumps": *SOEP Volume 3 – EIS*, p. 3-56, Table 3.3-15.

[191] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

[192] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Tables 3.8 & 3.9. Specific gravities to convert the tabulated volumes to weights are taken from pages 3-7 and 3-9 of the same report.

[193] The Proponents have not provided details of even the basic toxicity of these substances, let alone their ecotoxicological effects.

[194] *SOEP Volume 3 – EIS*, Fig. 3.2-1. This plan may have changed to one involving five drilling seasons, from 1998 to 2005 [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Table 3.2] though the present writer is not aware of any formal notification of such a change.

muds was abandoned in the North Sea by 1985[195] and, indeed, on the Scotian Shelf by 1980[196]. In their place, a variety of "alternative oil based muds" ("ABMs") and "low-toxicity oil based muds" ("low-tox OBMs"), using paraffin oils, have been developed. There have even been attempts to develop OBMs using non-mineral (animal, vegetable or synthetic) oils, though such muds do not yet seem to be in regular use[197]. The SOEP Proponents are currently planning to use low toxicity, mineral oil based muds ("LTMO muds", synonymous with "low-tox OBMs") for their OBM drilling[198].

Whatever the type of base oil, OBMs contain a similar mixture of major substances and additives to those included in WBMs. The Proponents have offered one composition for such a mud[199], without saying if it is their intention to use it. Converted to units of grams per litre, it is:

- Barite 800 $g.l^{-1}$
- Mineral oil 485 $g.l^{-1}$

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[195] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, p. 107.
The Proponents' consultants have stated that diesel based muds were replaced with low-toxicity ones because monitoring showed that the aromatic fraction of the diesel was affecting biota [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 3-8]. That is a serious mis-reading of the situation. Monitoring in the North Sea and elsewhere indicated that diesel-based OBM discharge affected benthic biota but it was purely an assumption that the toxic (largely aromatic) components of the diesel were to blame. Further monitoring over the last ten years has not shown a detectable difference in the degree of environmental effect caused by the two types of oil: Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 521-544; Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989) Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53. [See also: Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 3.3.5.1, comment ref. page 3-56.]

[196] Gordon, D.C. (ed.) (1988) An assessment of the possible environmental impacts of exploratory drilling on Georges Bank fishery resources. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1633: 31 p.

[197] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, p. 107.

[198] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 1-2.
The Proponents appear to restrict the term "ABM" to muds using synthetic oil as the carrier [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 3-7]. That is not a universal usage and other authorities have referred to all non-diesel based OBMs as "ABMs".

[199] *SOEP Volume 3 – EIS*, Table 3.3-13; MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Table 3.5.

- Fresh water 145 $g.l^{-1}$
- Calcium chloride 50 $g.l^{-1}$
- Calcium hydroxide 28-43 $g.l^{-1}$
- VERSAMUL (emulsifier) 23-28 $g.l^{-1}$
- VG-69 (treated bentonite) 6-9 $g.l^{-1}$
- VERSACOAT (wetting agent) 3-6 $g.l^{-1}$

This mud would have a specific gravity around 1.55.

Unlike WBMs, there is no routine discharge of OBMs at sea – they are re-cycled, re-conditioned, re-used and, ultimately, returned to land for safe disposal, as they have been since the early years of North Sea drilling. This does not, however, fully isolate the marine environment from the base oil of these muds since it has been conventional in offshore OBM drilling –though regulatory actions in some nations are changing the practice– to discharge the cuttings to the sea. Despite efforts to clean them, the cuttings inevitably carry a coating of OBM with them, amounting to 7-25% of their dry weight[200]. The quantity of barite, bentonite and other drill mud components discharged in this way is, of course, far less than if the same well were drilled with WBM which was then all discharged. However, it is the coating of oil, amounting to perhaps 100 tons from a fully OBM-drilled well and up to 25,000 tons per year for the North Sea as a whole[201], that is carried to the seabed with the cuttings and which has attracted so much attention over the past 20 years.

The SOEP Proponents have estimated that their drilling would result in the discharge of 86 to 217 m^3 per well of mineral oil in this way, for a total of nearly 4,000 m^3, or some 5,000 tons over the entire drilling period[202]. These calculations assumed that the OBM cuttings would be released with an oil coating amounting to the present guideline limit of 15% dry weight of cuttings. The Proponents also hope to be able to reduce this coating to smaller amounts, with a corresponding decrease in the total discharged.

OBMs contain the same array of potentially toxic substances as do WBMs, though it is generally supposed that the oil itself is the predominant environmental problem in OBM

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[200] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 521-544; Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.
The current guideline limit for such discharges, under the CNSOPB, is 15 g of oil per 100 g dry weight of solids discharged, averaged over a 48 hour period, with a one-time event discharge of 30%: MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pp. 1-3 & 3-10.

[201] Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53.

[202] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Tables 3.8 & 3.9. The density of the oil is drawn from Table 3.5.

drilling. More specifically, the naphthalene (about 2% of diesel fuel), phenanthrene and dibenzo-thiophene are thought to be the primary acutely-toxic components[203] – hence the various attempts to develop less toxic carrier oils. Unfortunately, experience in the North Sea suggests that the environmental effects of ABM and "low-tox" OBM drilling are little different to those that result from diesel-based OBMs[204]. The reasons are unclear but presumably the ecologically-harmful components of OBMs are not those that are acutely toxic in laboratory experiments and which have been eliminated from ABMs. While the use of ABMs and "low-tox" OBMs is probably to be preferred to that of diesel-based muds, the environmental effects of OBMs can be discussed without making much distinction of the type of oil involved.

5.4.4 Drill Cuttings

The drill cuttings discharged along with these muds are quite small chips of rock, though the exact size depends on the type of drilling and the nature of the rock (2 to 8 mm diameter from the exploratory wells on Georges Bank[205] and estimated to be 0.1-10 mm from the SOEP wells[206]). The quantity discharged depends on well depth and diameter but is, typically, around 1000 tons per well[207]. The SOEP Proponents have provided estimates of the expected amount of cuttings from their wells, which would range from 647 to 824 m^3 per well, and have estimated their specific gravity at 2.40[208]. This amounts to a weight of cuttings of 1,500 to 2,000 t per well – the depth and diameter required for these SOEP wells resulting in larger volumes of cuttings than the global average for offshore drilling The composition of cuttings also depends on the kinds of rock drilled, with heavy metals, radioactive materials and other contaminants occurring in the same concentrations as in the strata drilled through. No specific information has been provided for such details of the SOEP cuttings.

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[203] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53.

[204] Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 521-544; Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989) Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53.

[205] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

[206] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Fig. 3.2.

[207] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, pp. 103 & 106.

[208] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Tables 3.6 to 3.9. These discharges are those announced in *SOEP Additional Written Evidence* (pp. 14-19) and are substantially larger than those described in the EIS and used as a basis for the EIA. This is one of the major changes on the Proponents' part that have invalidated their EIA.

While they can be re-injected into the sediments or transported ashore for disposal, as is now required in some jurisdictions if OBMs are used, offshore drill cuttings have in the past usually been discharged to the sea directly from the platform or drill rig. The SOEP Proponents plan to discharge them through a pipe extending a few metres below the surface. The cuttings will then fall to the seabed, forming a pile perhaps 100 to 200 m in diameter, with a thinner layer extending beyond it, estimated to reach a few millimetres thickness a few hundred metres from the discharge point[209].

5.5 Fates and Effects of Muds and Cuttings

5.5.1 WBM Drilling

The discharges from WBM drilling would, to a degree, enter the water separately as cuttings and bulk mud discharges – even the mud coating on the cuttings would be partly washed off as they sank through the water. Thus, the two components of WBM drilling discharge can be considered separately.

5.5.1.1 WBM Cuttings

The WBM cuttings, some 30,000 tons in all from the SOEP wells[210], would settle to the seabed, where they would smother whatever they landed on. Their immediate impact would therefore be great, though the area affected would be very small – typically a few tens of metres across under each platform (see Section 5.5.3 for a discussion of the Proponents' site-specific estimates of these areas).

Following settlement, these cuttings should be re-distributed by normal seabed erosional and sedimentary processes, much like any other sand- and gravel-sized particles. In highly-energetic environments, they might be quite rapidly dispersed but elsewhere they would lie almost unmoved until a storm event eroded the cuttings pile. Indeed, in deep-water drilling, most cuttings can remain where they were deposited, with negligible movement[211]. Even on Georges Bank, with its extreme tides and with purely WBM drilling, the furthest detected movement of cuttings was only 2 km from the well site, despite monitoring being continued for three years after the drilling[212].

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[209] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-6.
Observations under a Californian drill rig have evidently shown most cuttings landing within 50 m of the rig: MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-2.
[210] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Tables 3.8 & 3.9.
[211] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370.
[212] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

Thus, it seems likely that the SOEP WBM cuttings would initially lie in low heaps under each platform, being slowly incorporated into the natural bottom sediments and dispersed around the bank, which is naturally composed of gravely-sand. (See Section 5.5.3 for a discussion of the Proponents' site-specific modelling of this dispersal.) There is, however, some reason to be concerned that these WBM cuttings will be capped by the OBM cuttings produced by later drilling of the same wells, which cuttings may resist erosion (see below) – a possibility that the SOEP Proponents do not seem to have considered.

The dispersed cuttings should have no effects on the environment at all. Even WBM cuttings piles, to the extent that they remained detectable for more than a few months and that they were free of over-lying OBM-contaminated cuttings, should eventually be colonized by benthos, though it might take some years for a fully-developed benthic community to appear. Only if the rock strata cut through were particularly toxic, perhaps with high levels of heavy metals, would this colonization be prevented. (The dispersed cuttings should be too diluted, amidst the natural sediments of the Bank, for any contaminants in them to have an impact on the environment.) Thus, aside from the initial loss of a very small area of benthic habitat directly under the platforms, WBM cuttings should not cause adverse effects on the marine environment.

5.5.1.2 WBM Mud Components

The WBM itself, both that lost routinely with the cuttings and that released in bulk discharges, would contain the many noxious and toxic components described above. Most of them would only be released in very small quantities and would be rapidly dispersed in the water column. They are, therefore, generally ignored in discussions of the impacts of WBM drilling. Clearly, this is inappropriate and potentially dangerous, though the wide variety of possible materials and the lack of study of their effects makes any more detailed treatment impossible. Suffice to say that most of these components should have no adverse effects on the marine environment but that experience may yet show that some of them do.

One group of minor mud components that gives some cause for concern is the heavy-metal impurities. They have been detected as far as 1 km from some North Sea platforms[213]. At that range, however, they are unlikely to make more than a small supplementary addition to the other environmental effects of the platform and its operations. While they should not be ignored, they can be passed over for present purposes.

The primary concern with WBM, however, remains its content of barite and bentonite, which would be released in large quantities. Even though composed of fine, mud-like particles that would ordinarily be transported long distances be even weak currents, much of this material can be carried rapidly towards to seabed, either in a descending jet during a

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On Sable Island Bank, observations around the COPAN platform (four months after drilling ceased, with a winter storm season in between) detected a mobile bedload of what may have been drill cuttings at a few points, though neither their distances from the platform nor the quantities of material involved have been stated in published reports. Nor is it clear whether there was still a visible cuttings pile at the well site: Muschenheim, D.K., T.G. Milligan & D.C. Gordon (1995) New technology and suggested methodologies for monitoring particulate wastes discharged from offshore oil and gas drilling platforms and their effects on the benthic boundary layer environment. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2049: 55p.

[213] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, p. 112.

bulk discharge or else after flocculating on contact with seawater and subsequently acting as though composed of much larger particles than these materials actually are. At the SOEP sites, it is expected that the bulk of the WBM would reach near-bottom depths within 200 m, and usually within 50 m, of the discharge point[214]. Thereafter, it would largely be of concern for its potential impacts on the seabed, rather than the water column, environment.

It was barium in such barite that the monitoring of the early 1980s detected 65 km from the well sites on Georges[215]. From the SOEP sites (if. in fact, barite is used in the WBM for the SOEP drilling), it would likely disperse broadly and generally across Sable Island Bank, eventually either dissolving slowly into the seawater (which barite does[216]) or else settling in lower-energy environments around the fringe of the Bank and becoming incorporated into the sediments there. One might speculate that the bulk of the WBM barite that SOEP could discharge would come to rest on the floor of the Gully, in its deeper parts east of Sable Island, or else on the continental slope southwest of the platform sites, those being the most likely receiving areas. From there, geological processes would eventually carry it to the deep ocean floor.

Fortunately, barite seems relatively innocuous to most marine animals[217]. Laboratory experiments have shown barium uptake, from WBM-contaminated sediments and foods, by both flounder and lobster juveniles but there does not seem to be any evidence for its biomagnification up the food chain[218]. In the experimental setting, the contaminants suppressed growth of both species and enhanced lobster mortality but this was with concentrations of 9 g barium per kilogram of sediment and a 98 or 99-day exposure – concentrations unlikely to be found offshore for such a prolonged period.

The final fate of the WBM bentonite would, perhaps, be similar to that of barite. Certainly, its finer grain size should ensure that it is at least as mobile as the barite and probably more so. Unfortunately, it might be environmentally damaging before reaching deep water. Recent research has shown that scallops are peculiarly susceptible to bentonite, prolonged exposure to even concentrations as low as 10 $mg.l^{-1}$ (less than 10 ppm) being fatal, while levels as low as 2 $mg.l^{-1}$ can affect scallop growth[219]. Little is known about how far from a

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[214] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pp. 2-1 & 2-3. At deeper sites, such as those on Grand Bank, drill muds can be dispersed into the water column, before reaching bottom, leading to different environmental effects.

[215] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

[216] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.

[217] DFO, however, appears to have evidence showing that drill-mud barite is as harmful to scallops as is bentonite. That evidence has not been seen by the present writer but, when available, would over-ride comments here about the innocuous nature of barite. See: Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 5.3.1.2.

[218] Neff, J.M., R.J. Breteler & R.S. Carr (1989) Bioaccumulation, food chain transfer, and biological effects of barium and chromium from drilling muds by flounder, *Pseudopleuronectes americanus*, and lobster, *Homarus americanus*. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes*. Elsevier, London & New York: 439-459.

[219] Cranford, P.J. & D.C. Gordon (1992) The influence of dilute clay suspensions on sea scallop (*Placopecten magellanicus*) feeding activity and tissue growth. *Netherlands Journal of Sea Research*

drill site 2 ppm or 10 ppm concentrations of bentonite might extend on Sable Island Bank. What is known is that sediment concentrations in the lowest levels of the benthic boundary layer of the water column (levels in which scallops live and from which they draw their food) can be 100 times higher than those only a few metres above the bottom. In one survey, around a COPAN site at which drilling had been proceeding for seven months, tidally-resuspended bentonite was found at detectable levels even at the most distant station sampled, 8 km from the platform, though the concentrations there seem to have been around 0.01 ppm and so should not have been high enough to affect scallops[220]. What significance these results may have for scallop growth and survival around SOEP platforms remains unsure. There is the potential of some suppression of production, through reduced growth and increased death rates, of this valuable resource within a few kilometres of each platform while drilling is in progress – though that would affect only involve one or two, or in the case of *Venture* five, seasons at each platform site[221].

All of these firmly-established numbers may, however, conceal a greater problem for scallops. The research to date has, for obvious reasons, examined the effects of bentonite on adult scallops – finding it to be more harmful than many would have expected. What has yet to be considered, however, is the impact of bentonite, lying on the seabed or suspended in the benthic boundary layer, on settling scallop larvae ("spat"). Scallops, like most marine benthic species, have planktonic larvae that must, at a short and critical phase in their life cycles, select a point on the seabed where they will settle. While no definite information is available, it is likely that these scallop spat and their selection activities are more vulnerable to the impacts of contaminants than are adult scallops. Thus, it is possible that the bentonite distributed about active drilling operations would reduce scallop recruitment for some kilometres around the wells, in the year of the drilling. The degree of any such reduction can only be a matter for speculation at the present time.

It should also be noted that this discussion addresses effects on scallops for no other reason than that their economic importance on Georges Bank has caused them to be studied. While scallops are certainly far from being the least sensitive species, other benthic filter feeders may be as sensitive, or even more sensitive, to bentonite than scallops are. Scallops therefore serve as a model of possible effects on the benthos, as well as being a commercially-important component of it, but they are not the only species of concern[222].

30: 107-120; Cranford, P.J. (1995) Relationships between food quantity and quality and absorption efficiency in sea scallops *Placopecten magellanicus* (Gmelin). *Journal of Experimental Marine Biology and Ecology* 189: 123-142; Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 5.3.1.2.

[220] Muschenheim, D.K., T.G. Milligan & D.C. Gordon (1995) New technology and suggested methodologies for monitoring particulate wastes discharged from offshore oil and gas drilling platforms and their effects on the benthic boundary layer environment. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2049: 55p.

[221] *SOEP Volume 3 – EIS*, Fig. 3.2-1. [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Table 3.2 suggests a rather different schedule.]

[222] At least bentonite should not have any effects on species higher in the food web, other than perhaps by reducing the availability of their food. Scallops, and probably other filter feeders, reject the clay particles as they would natural clay and thus do not incorporate any amount of it into their bodies where predators might encounter it.

Unfortunately, since so much research has focused on the effects of OBM-coated cuttings, few studies have been made of the overall ecological impacts of WBM drilling. The monitoring on Georges found that the benthos at one station, 6 km west of one drill site, was similar to that 6 km to the east of it before the drilling. Afterwards, the benthos at the 6 km west station resembled that 200 m from the well. This might indicate that an ecological effect of the drilling extended at least 6 km down-current but winter storms had moved fine sand over much of the study area in the interim, though without covering the 6 km east station. Thus, it is possible that the observation represents nothing more than the appearance of a "fresh sand" community from the drill site westwards, replacing earlier communities[223]. Otherwise, there have been a few studies around WBM-drilled wells in the southern North Sea[224] which have shown that WBM causes lesser, and less persistent, impacts near the site than does OBM. Since those studies were, in their original design, typical of the ones that failed to detect the medium-range effects of OBM drilling, however, their inability to detect impacts of WBMs should not be taken as evidence of any lack of such impacts.

5.5.2 OBM Drilling

When drilling with OBMs, the only drill mud discharged (barring accidents) is a coating on the cuttings. Being water-repellent, most of it remains with the cuttings as they fall to the seabed. The muds and the cuttings from such drilling can, therefore, be considered together.

As with WBM cuttings, those from OBM drilling fall to the seabed, directly beneath the platform and, once there, they smother a very small area of seabed, just as WBM cuttings do but with the added problem of laying toxic concentrations of oil across the seabed. This both adds to the lethal effect of the smothering and tends to block access to oxygenated water, leading to anoxic conditions within the cuttings pile. OBM cuttings piles destroy all that was beneath them and, through the lack of oxygen and the presence of oil, limit any re-colonization.

The OBM cuttings, being coated in water-repellent oil, tend to adhere to one another, such that OBM cuttings piles can resist erosion even in highly energetic environments. In the northern North Sea, there has been essentially zero distribution of the cuttings piles under offshore platforms – causing a very serious and very expensive environmental problem now that the fields are running out and the platforms must be removed[225]. In the more energetic southern North Sea, the evidence is less clear, though OBM-derived oil and barite have been seen in high concentrations very close to well sites several years after drilling ended and it is likely that cuttings (which are less detectable) were present also. It seems that OBM cuttings piles in such environments are spread across the bottom and buried under new sand movements more than they are dispersed[226].

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[223] Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114.
[224] e.g. Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.
[225] Pearce, F. (1996) Toxic legacy of Britain's oil boom. *New Scientist* 7 December 1996, p. 4.
[226] Daan, R., H. van het Groenewoud, S.A. de Jong & M. Mulder (1992) Physico-chemical and biological features of a drilling site in the North Sea, 1 year after discharges of oil-contaminated drill cuttings. *Marine Ecology Progress Series* 91: 37-45; Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.

The relevance of these results to drilling on Sable Island Bank is in dispute[227]. The SOEP Proponents have suggested that 80 to 90% of OBM cuttings at the *Venture*, *South Venture* and *Thebaud* sites would be dispersed in a single season[228]. That, however, is a result that seems to be drawn from their consultants' models which, in so far as can be judged from the report on the modelling[229], did not take the adhesion of the cuttings into account. It is known that "relict" cuttings remain at abandoned drill sites elsewhere on the Bank[230] and there has been some persistence of piles of oiled cuttings at the COPAN drill sites[231]. Indeed, Environment Canada has described the immediate area around the latter sites as "biologically dead" and has noted that "improvements are slow to occur"[232]. Thus, some tendency for oiled cuttings to remain near the drill site, albeit in a layer buried by other sand, rather than as a pile, should be expected at all of the SOEP sites, even *Venture*. At the deeper sites, there does not seem any reason to reject the hypothesis that much of the cuttings would remain in a distinct pile, with the OBM ones capping the cleaner WBM ones beneath.

Although the bulk of these cuttings could thus stay in a pile, the associated OBM would spread slowly outwards – in all directions through with a bias down the residual current flow. After a short time, the total oil content of the surficial sediments within 250 m of a platform with OBM-drilled wells is typically raised to 1000, or even 10,000, times background levels, though such concentrations drop to background levels within a some

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It may be noted that, in their generally well-balanced presentation of the environmental effects of drill muds and cuttings, the Proponents' consultants have given a less-than-complete summary of Daan and Mulder's results [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-3]. They follow Daan and Mulder's abstract in saying that OBM traces were only found within 1 km of the discharge point and effects on the benthic community at over 1 km [MacLaren Plansearch say 1 to 2 km]. In fact, in some years of their survey, particularly 1990, Daan and Mulder found elevated hydrocarbon concentrations 5 km from the drill site, presumably as a result of re-distribution of oiled sediment. They also found differences in the densities of several species between their two outer stations, at distances of 1 and 5 km from the site. Those showed that community effects extended beyond 1 km but gave no indication of whether or not the 5 km station was also affected to a lesser extent. Daan and Mulder's own conclusion was:

> The spatial extent of initial effects of OBM cutting discharges as estimated around drilling locations in the Dutch sector is in good agreement with results from the Norwegian sector, where the area affected ranged from 3 to 5 km from well sites

and that despite the studied site, K12a, having seen only five wells drilled.

[227]. When asked to explain this discrepancy, the Proponents evaded the question, supplying assorted information but not an answer to the question posed (*SOEP Response to Ecology Action Centre Information Request* 14).

[228] *SOEP Response to Panel Information Request* 2.16.

[229] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pag.var.

[230] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 3-17.

[231] *SOEP Response to Panel Information Request* 2.20.

[232] Letter from A.R. McIver, Environment Canada, to the Secretariat of the Joint Review Panel, 4 February 1997, point #1.

kilometres[233]. This oil is not, however, instantly lethal to all it contacts. Very high concentrations do exclude almost all life but slightly lower ones can serve as a food source for micro-organisms, enriching local production and supporting a community of hydrocarbon-tolerant animals. Further from the cuttings pile, with lower concentrations of oil, a wider variety of benthic animals can live and microbial breakdown of the oil may also proceed faster. Yet further way, the ecosystem is unaffected by the OBM. The question is at what distances from the platform these various stages occur.

Measured benthic diversity is inversely correlated to total oil concentration in the North Sea, at all levels from less than 10 ppm upwards. It is thus not surprising that diversity is strongly depressed within one or two kilometres of OBM-drilled well sites and in some cases as far away as 5 km[234]. Individual species react in more complex ways, of course, with some becoming extremely abundant either directly under the platforms or at some little distance, where there is an intermediate oil concentration[235]. The relative decrease in

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[233] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984. Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370) estimated this distance as 3 km for the United Kingdom sector of the North Sea, though their own figures suggest that 5 km would have been more realistic and GESAMP (1993. Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, Table 5.6) suggested that it could be as much as 8 km. For the Norwegian zone, Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989. Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117) suggested that 3 to 5 km was typical and, down current of the *Statfjord B* platform, they found 22 ppm total hydrocarbon as far as 12 km from the platform – a distance reported by GESAMP (1993. Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50, Table 5.6) though without citation of a published source.
There has also been an interesting observation as part of the monitoring of the COPAN drilling, in which apparent traces of OBM base oil were found in blue mussels placed in moored cages at distances of up to 10 km from the wells. This observation is currently in dispute, however, as it seems that mussels can naturally carry aliphatic hydrocarbons that may have confused the monitoring analyses.
Any disagreement over the exact distances at which OBM hydrocarbons can be detected is, in any case, probably less critical than doubts over the nature of a "background" concentration and weak capabilities to detect minor deviations from it. Suffice to say that hydrocarbons in sufficient concentration to affect biological processes can be found several kilometres from wells drilled with OBMs under some circumstances.

[234] Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 521-544.
The Proponents' consultants have described such changes in diversity as "subtle" [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-6]. In fact, diversity is a very crude measure of biological communities which can undergo very severe perturbation before a change appears in a measured diversity index [e.g. Warwick, R.M. & K.R. Clarke (1991) A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244]. A measured change in diversity should be regarded as confirmation that significant ecological change has taken place, while environmental protection should also seek to prevent the truly-subtle changes that do not affect diversity.

[235] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.)

abundance of the more sensitive types (apparently caused by oil[236]) represents a change in community composition that has been detected, using multi-variate statistical methods, as far as 3.5 km from the *Ekofisk* facility[237] and 6 km from the *Valhall* production platform[238], each of which had multiple OBM-drilled wells. Even this latter is, however,

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Drilling Wastes. Elsevier, London & New York: 521-544; Kingston P.F. (1992) Impact of offshore oil production installations on the benthos of the North Sea. *ICES Journal of Marine Science* 49: 45-53.

[236] Scallops, for example, are said to potentially affected by OBM concentrations as low as 0.1 ppm [Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 6.3.1.1, ref. page 6-9].

[237] Warwick, R.M. & K.R. Clarke (1991) A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244.

[238] Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.

Olsgard and Gray's work has met with the sort of opposition that might be expected of any seminal research paper that required changes in long-held views and one that threatened the operations of a major industry. To the present writer's knowledge, however, nobody has yet questioned the statistical basis for those authors' conclusions. Olsgard and Gray's central analysis involved a number of steps, complex in their execution but not hard to understand. They were, with some minor simplification:

1. The various stations in each survey (around a given platform in a given year) were grouped into clusters (using a "Classification Analysis" technique), based on the similarities among the species found at each one.
2. Using the same data and a multivariate statistical technique known as "Non-metric Multidimensional Scaling Analysis" ("MDS"), the stations were plotted on a graph, the axes of which represent patterns of variation in the benthic communities encountered by the surveys –the principal one being, in the presence of high hydrocarbon loadings, closely correlated to the concentrations of hydrocarbons in the sediment.
3. The groups of stations identified by the Classification Analysis were then marked on the MDS graphs.
4. That cluster of stations which lay at low values of the hydrocarbon-associated MDS axis was judged to represent background conditions and the distance to which the effects of the OBM extended was taken as the maximum distance from the platform to a station in the next-least-affected cluster.

This analytical approach is as advanced as any currently available for its purpose. It does, however, have flaws. The central problem is that Classification Analyses are designed to create clusters of objects (stations in the present case) and they will do so from any data set presented to them – including random data. If the data were drawn from points along a steady gradation, as is likely radiating out from an OBM cuttings pile, Classification Analyses cannot return a representation of such a gradient but must break it into apparently-discrete groups. A single station, near one of the break-points, must be clustered to one side of it or the other even if the species composition there lies exactly mid-way between the two groups. Which one it falls into can be influenced as much by the chances of the field sampling as by the average species composition in the vicinity of the station.

In Olsgard and Gray's method, this characteristic becomes critical. Their observation that the effects of drilling extended to 6 km depended on three stations at that distance and three at 4 km clustering together but apart from either those closer to the platform or those further away (see their Fig. 10). Had the 6 km stations chanced to cluster with the reference stations at 15 km distance, the affected area would have been reduced to 4 km. Clearly, as applied to their data, the analytical approach does not provide precise estimates of the extent of that area with a high degree of confidence.

In the case of the *Valhall* surveys, however, this problem is almost certainly over-ridden by a second one. The field data were collected along four transects, centred on the platform and disposed at 90° to one another.

only a minimum estimate of the distance at which community composition was affected, the arrangement of survey stations preventing any analysis for more distant points, so that all that can be said with certainty is that offshore discharge of OBM cuttings seems to influence the benthos within several kilometres of the drill sites – at least, in the northern North Sea and around locations where multiple wells were drilled with OBMs.

The ecological and economic significances of these changes are almost unknown. One of the most oil-sensitive species in the area around *Valhall* was the brittlestar *Amphiura filiformis* which is known to be a major food item of some commercial groundfish species in the North Sea, as well as a key component of the benthic community there[239]. Thus, the environmental effects 5 to 10 km from OBM drilling of multiple wells may be ecologically and economically significant but that remains unsure.

Off Sable Island, OBM discharge would clearly cease as soon as drilling was replaced by gas production, though SOEP (like many other projects) is intended to have on-going drilling as the gas reservoirs are tapped through the life of the project and thus mud discharge would continue intermittently. Once it ceased at any particular site, environmental recovery would begin, though its progress is likely to be irregular. One study around a single exploratory gas well that was drilled with OBM in 1987 in the southern North Sea found substantial recovery after three years. This was not, however, the result of a gradual process but rather of a short-period, storm-induced movement of sediment across the whole area. The new seabed seems to have been rapidly colonized by meiofauna, which showed no response to the former drill site, through a gradient in macrofaunal composition could still be detected to a distance of at least 2 km from the site and perhaps to 5 km[240]. These larger animals may have burrowed deeply enough into the seabed to encounter the oiled sediments below the new layer, whereas the smaller meiofauna remained within the

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The outermost station on each transect was at 6 km from the platform, with the next nearest at 4 km. Such a survey design, when combined with Olsgard and Gray's analytical technique, would be incapable of detecting any symmetrically-distributed environmental effect at more than 4 km, since the outermost stations would serve as measures of the "unaffected" background. For their 1991 survey, however, they had added two reference stations at 15 km distance, allowing detection of an effect at 6 km.

It would still be closer to the truth to say that they detected a difference between the species composition of the benthic communities at 6 and 15 km from the platform that was consistent with the effects of hydrocarbon in the sediment and thus appeared to be caused by discharges (presumably OBM) from the platform. Where, between 6 and 15 km, the actual limit of detectable change lay or, indeed, whether the stations at 15 km distance would have also shown hydrocarbon-related differences in species composition when compared to points at a still greater distance must remain matters for speculation until more extensive fieldwork is completed.

Much the same could be said of Warwick, R.M. & K.R. Clarke's (1991. A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244) earlier study.

[239] Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.

[240] Daan, R., H. van het Groenewoud, S.A. de Jong & M. Mulder (1992) Physico-chemical and biological features of a drilling site in the North Sea, 1 year after discharges of oil-contaminated drill cuttings. *Marine Ecology Progress Series* 91: 37-45; Heip, C. (1992) Benthic studies: Summary and conclusions. *Marine Ecology Progress Series* 91: 265-268; Kröncke. I., G.C.A. Duineveld, S. Raak, E. Rachor & R. Daan (1992) Effects of a former discharge of drill cuttings on the macrofauna community. *Marine Ecology Progress Series* 91: 277-287.

uncontaminated upper layer[241]. Elsewhere in the Netherlands sector, the sediments around field K12a still showed elevated sediment hydrocarbon levels eight years after five wells were drilled there using OBM and little evidence for the degradation of the OBM base oil was seen over that time. It had, however, moved deeper into the sand, much of it being 20 to 100 mm down after the first four years and the greatest concentrations being below 250 mm eight years after drilling[242]. It seems likely that this was caused by the transport of sand into the area, burying the contaminated sediment, rather than by any downward percolation of the oil, though that cannot be certain.

Another study, around the *Murchison* field in the deeper and less energetic northern North Sea, found some improvement very close to the platform (150 to 250 m away, three years after drilling ceased) but little change 2 km away[243] and even some continued loss of diversity at the 500 and 1000 m stations[244], perhaps because hydrocarbon residues were being gradually transported outwards from the highly-contaminated central zone – a process that has also been noted around the *Ekofisk* field[245]. This gradual outward movement may be less likely on Sable Island Bank since any material dislodged from the basic cuttings deposit would be expected to be rapidly dispersed. Thus, one might expect a rapid achievement of a steady state, in which continued "leakage" from a relict cuttings pile maintained elevated sediment hydrocarbon loads in a zone perhaps a few kilometres wide around the site. Certainly, while Sable Island Bank may be even more energetic than the southern North Sea, the Proponents' claim that recovery would been seen around *Venture*, *South Venture* and *Thebaud* after a single winter following the completion of dredging[246] seems rather optimistic.

For the northern North Sea, it was early hypothesized[247] that low concentrations of oil would eventually be biodegraded but that the anaerobic conditions in the main piles of cuttings directly under the platforms would prevent that, such that areas of oil-rich

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[241] Stebbing, A.R.D. & V. Dethlefsen (1992) Introduction to the Bremerhaven Workshop on Biological Effects of Contaminants. *Marine Ecology Progress Series* 91: 1-8.

[242] Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.

[243] Mair, J.McD., I. Matheson & J.F. Appelbee (1987) Offshore macrobenthic recovery in the Murchison Field following the termination of drill-cuttings discharges. *Marine Pollution Bulletin* 18: 628-634.

[244] Davies, J.M., D.R. Bedborough, R.A.A. Blackman, J.M. Addy, J.F. Appelbee, W.C. Grogan, J.G. Parker & A. Whitehead (1989) The environmental effect of oil-based mud drilling in the North Sea. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 59-89.

[245] Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.

[246] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-6. Their claim of rapid dispersion seems based, in part, on the relatively small amount of oil expected to be left on the cuttings by the advanced cleaning equipment to be used by SOEP. This lesser amount of oil should result in reduced cohesion of the cuttings and so more rapid dispersal [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 2-12].

[247] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370.

sediments would remain and eventually be capped by natural sedimentation. Later mesocosm research supported that hypothesis, indicating that a partial recovery from a 3 mm coating of OBM cuttings was achieved within five years, whereas sediment covered by a 10 mm layer (whether from OBM or ABM drilling) essentially prevented all macrobenthic re-colonization in that time, despite much reduction in sediment hydrocarbon levels in the interim[248]. It seems likely that similar resistance to re-colonization would be seen at any SOEP sites where discrete cuttings piles remained. If the OBM cuttings are spread out around the shallower sites, however, oxygen and hydrocarbon levels may be such as to allow slow biodegradation and eventual full recovery. Any burial would, however, slow this process, leading to indefinite local hydrocarbon contamination.

5.5.3 The SOEP Models

Subsequent to the preparation of their EIA, the SOEP Proponents have commissioned an extensive modelling effort, designed to predict the fates of these various drilling discharges, and have provided a very thorough report on that work[249]. It has not been possible to undertake a proper technical review of this modelling during the preparation of the present report but that work appears to address most of the relevant issues and to use advanced, up-to-date models. The results of this modelling[250] can be summarized as follows:

- The cuttings would initially form notable mounds, with the highest at the shallowest platforms (especially *Venture*) due to the lesser dispersal caused by the small difference between discharge and bottom depths.
- The *Venture* mound would be up to 3.5 m high, with a thickness tapering to 1 mm at 500 m from the discharge point.
- The *Venture, South Venture* and *Thebaud* cuttings piles would be dispersed to the point of being undetectable within one year.
- In the deeper water of the *North Triumph*, *Glenelg* and *Alma* sites, major dispersal would require a storm of the intensity expected, on average, once per four years. Thus, the cuttings piles could remain for a number of years.
- Smothering of benthos is expected to be confined well within 500 m of the platform sites.
- The concentration of bentonite from WBM in the benthic boundary layer is expected to be below the 10 ppm known to be fatal to scallops at all points beyond 1 km from each platform and below 1 ppm at a distance of 10 km. Even these concentrations are expected to be dispersed in the first winter storm season following drilling.

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[248] Bakke, T., J.A. Berge, K. Naes, F. Oreld, L.-O. Reiersen & K. Bryne (1989) *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 521-544.
The 1,000 tons of cuttings from a typical well would cover a circle of less than 100 m radius to a depth of 10 mm, while a real cuttings pile would not be so evenly distributed. Thus, even with multiple wells drilled under a single platform, the area covered a semi-permanent pile of oiled cuttings would be small.

[249] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pag.var.

[250] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, Section 6.

- Most cuttings and mud components would be greatly dispersed before reaching the Sable Gully and would be at parts-per-trillion concentrations by the time they reached there. Some might concentrate at the known "hydraulic fence" at 140-200 m depth around Sable Island Bank, where finer particles are deposited between two zones of faster water movement, but their ultimate fate would still likely be settlement in depositional areas at great depth.

The estimates of cuttings dispersion seem, however, to have been based on a model that did not include the adhesive effects of OBM[251]. If the cuttings are actually as cohesive as OBM cuttings have proven to be elsewhere (an uncertain assumption, given the attributes of modern drill muds and cuttings-cleaning equipment) and considering that the OBM cuttings from each well would over-lie the WBM cuttings, sealing them below an oiled layer, dispersion rates might be very much lower than these model results suggest. It is not possible, on the basis of these modelling results alone, to reject the suggestion given above that the SOEP OBM cuttings would be persistent at the drill sites.

Furthermore, the Proponents' consultants have interpreted their results relative to an estimate that, aside from particular sensitive species, the threshold level of sediment hydrocarbon concentration for effects on benthic community structure is around 1,000 ppm[252]. That is entirely contrary to North Sea experience, where even coarse indicators, such as diversity indices, show responses at levels below 10 ppm[253]. While the Proponents' preferred low-toxicity base oil may serve to allow higher concentrations for the same level of effect, such a dramatic difference is unlikely. In any event, changes in diversity represent gross alterations to community structure and hence the acceptable level of hydrocarbon contamination should be far below that causing such a change. Hence, the Proponents' limiting value is perhaps a hundred times too high and the resulting interpretations of the model output, including that setting a 3 km limited on demonstrable change in the benthos, are of no value[254]. Unfortunately, their report does not include maps

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[251] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 5.19.

[252] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 6-2.

[253] Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead & T. Wilkinson (1984) Environmental effects of the use of oil-based drilling muds in the North Sea. *Marine Pollution Bulletin* 15: 363-370; Reiersen, L.-O., J.S. Gray, K.H. Palmork & R. Lange (1989) Monitoring in the vicinity of oil and gas platforms; results from the Norwegian sector of the North Sea and recommended methods for forthcoming surveillance. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 91-117.

[254] Even the Proponents' consultants cite a study showing that biodegradation of their oils is inhibited at sediment concentrations above 800 ppm [MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 6-2] suggesting that the biotic community is very much affected at that level.

They also present DFO's conclusions of the concentrations of bentonite that are harmful to scallops in contrast to results from surveys in the Netherlands sector of the North Sea that showed no detectable environmental effect of WBM drilling as though the two were in conflict [Cranford, P.J. & D.C. Gordon (1992) The influence of dilute clay suspensions on sea scallop (*Placopecten magellanicus*) feeding activity and tissue growth. *Netherlands Journal of Sea Research* 30: 107-120; Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES* of the sediment hydrocarbon concentrations predicted by their models and so the extent of, say, 10 ppm levels remains unknown.

I also remain unconvinced by the claim that there would be negligible concentration of previously-dispersed drill mud materials in deeper parts of the Sable Gully. The model approaches used by the Proponents' consultants do not address such deposition and the verbal arguments that they have offered[255] are unconvincing – they adequately state the undoubted dispersal of these muds across Sable Island Bank but dismiss (rather than adequately refute) the possibility of subsequent concentration. That is not to say that such concentration occurs and certainly not that it raises the level of any substance to a harmful point. However, those possibilities have not yet been adequately dismissed by the Proponents' submissions.

5.6 Summary

As with other aspects of their project, the primary conclusion from the Proponents' submissions relating to drilling discharges is that they have, to date, failed to provide enough information to support estimates of the likely extent of any impacts. Even such useful material as they have provided came too late to be incorporated into their EIA, which indeed was based on estimates of mud and cutting volumes far below those later put forward. This is simply inadequate for the Panel's review.

The Proponents did acknowledge the potential for drill muds and cuttings to have an impact on benthos[256], though they only considered that it could affect three resource species: scallops, propeller clams and quahogs[257], thus missing its potential effect on the general benthos (notably benthic filter feeders other than the resource species but also all organisms in smothered areas), as well as the possibility of an effect on other resource species, such as haddock, mediated through ecological pathways from the benthos[258]. Aside from the potential for tainting of scallops outside the platforms' safety exclusion zones, the Proponents considered that there would be no significant effects of these drilling discharges, though slower growth and smothering of "a small number of organisms" within the exclusion zones were admitted. As they applied to scallops, the slower growth and smothering seem to have merited a "minor" (an thus "insignificant") impact rating[259].

Journal of Marine Science 53: 1036-1044; MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 6-2]. In fact there is no conflict: the sea scallop, *Placopecten magellanicus* does not occur in the North Sea and it is not certain that an equally sensitive species exists off the Netherlands, while Daan and Mulder only compared stations out to 5 km from their WBM wells, finding no detectable differences in species number or summed abundance over that distance. It is most improbable that they would have detected the sort of impact postulated for scallops on Sable Island Bank with such a study, even if it had occurred.

[255] *SOEP Response to Panel Information Request* 2.17; *SOEP Response to Ecology Action Centre Information Request* 15; *SOEP Response to Ecology Action Centre Information Request* 9 (Addendum); MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, p. 6-4.

[256] *SOEP Volume 3 – EIS*, pp. 5-9 & 6-3 to 6-10.

[257] *SOEP Volume 3 – EIS*, p. 5-18.

[258] cf. Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 5.3.

[259] *SOEP Volume 3 – EIS*, Table 6.3-1.

The Proponents even admitted to residual impacts as a result of these discharges, including loss of productivity due to smothering and to the toxicity of the muds, though they claimed the latter would only occur within the 500 m safety exclusion zone[260]. Since these impacts were determined before the Proponents greatly increased their projections of mud and cutting discharges[261] and long before they had the results of their modelling of dispersal of those discharges[262], these declared impacts can perhaps be quietly forgotten. They certainly have no relevance to the actual impacts that the SOEP drilling would have on the marine environment.

Those actual impacts remain impossible to estimate, without much more information as to the Proponents' intentions. Aside from smothering under the platforms, some persistent hydrocarbon contamination around each site seems likely, with concentrations sufficient to affect benthic community composition extending for some kilometres. Bentonite, and perhaps barite, release may kill, slow growth of, or impede spat settlement by scallops for several kilometres around each site, though only in the years that drilling continued. There is some possibility of a concentration of contaminants in deep, sedimentary basins around the Bank (though that remains in dispute) but otherwise all of these effects should be confined to areas with say 10, or at most 20, kilometres of the drill sites.

The worst of these problems would, however, result from the Proponents' decision to discharge OBM cuttings at sea – an action that is not only (technically) unnecessary but would be banned in most countries that have long experience of offshore drilling in cold-temperate environments, including Norway, Denmark, Germany and the Netherlands[263]. Even the United Kingdom does not permit the amount of OBM discharge that the SOEP Proponents intend[264]. When questioned on the reasoning behind their decision, the Proponents have stated that they are continuing to investigate the possibility of substitutes for OBM but that no other drilling mud has proven satisfactory when directionally drilling the unstable shales of the Sable Island area. They have also stated that they have considered on-shore disposal of OBM cuttings but rejected it on the grounds of cost and the results of the EIA (presumably those suggesting that at-sea disposal was environmentally harmless)[265]. These would be reasonable arguments if, indeed, the discharge of OBM

[260] *SOEP Volume 3 – EIS*, Table 7.7-1. Environment Canada has given the opinion that containment of OBM effects within the exclusion zone "is not considered adequate mitigation" [Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project*, p. 7].

[261] *SOEP Additional Written Evidence*, pp. 14-19.

[262] MacLaren Plansearch (1991) Ltd. (1997) Phase A – Interim report: Physical fate of drilling and production effluent discharges and impact on marine environment: Part 1: Drilling waste discharges. *Report for Sable Offshore Energy Project*, pag.var.

[263] Daan, R. & M. Mulder (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. *ICES Journal of Marine Science* 53: 1036-1044.

[264] CORDaH (1997) Review of the environmental effects of the deposition of oil based drill cuttings and release of oil based muds. *Report prepared for Mobil Oil Canada Properties Ltd.* 14p.
When asked why they planned to discharge OBM cuttings in a manner not permitted in the North Sea, the Proponents' only answer was, in effect, that they would follow current Canadian guidelines (*SOEP Response to Ecology Action Centre Information Request* 13). According to a comment from DFO, even that is not strictly true, since those guidelines apparently require that proponents show that OBM drilling is required and also recommend re-injection of oiled drill wastes, which the SOEP Proponents do not address in any of their submissions [Department of Fisheries and Oceans, Maritimes Region Science Branch (1997) *Information Request to Mobile/Shell filed with Panel Secretariat* point 3.3.3.1].

[265] *SOEP Response to Environment Canada Information Request* 1.

cuttings was harmless. Since it is not, either a delay in the project until improved non-oil-based muds become available or else mandatory on-shore cuttings disposal, as is now required in most North Sea nations, should be very carefully considered.

Canada has almost no offshore petroleum industry and our regulatory agencies have yet to face the problems with oiled cuttings piles that more experienced national governments are now all too familiar with. As the first Canadian offshore proposal advanced since the revolution in scientific understanding of the environmental effects of offshore drilling, of the late 1980s and early 1990s, revised regulations and standards must be prepared for SOEP. Unless a very good argument can be advanced for the at-sea discharge of oiled cuttings, I recommend that those new standards follow the European lead by barring the release of all OBM cuttings.

Even if deemed unnecessary for SOEP's planned 28 wells, this will become very highly desirable if, as expected, SOEP's success leads to wider development of Scotian Shelf gas and oil reserves. If the 28 should become 280, the extent of oiled sediments on the Bank and in possible deposition areas, such as the Sable Gully, could well become unacceptable. The time to prevent this is, I suggest, at the start of this new development.

6. Routine Production Discharges

Once the wells were drilled and gas production commenced, the nature of the discharges from SOEP's offshore installations would change. In the production phase, they would include an assortment of chemicals and wastes of various kinds, all of which are discussed in Section 6 below, while there would be some risk of major losses of hydrocarbons as a result of accidents (see Section 8). However, the principle routine discharges and emissions during this phase would comprise produced water, produced sand, flared gas and emitted energy – heat, light[266] and sound. All of these are considered in the present Section. Petroleum production can also lead to the deposition of natural, radio-active material from the hydrocarbon-bearing rock strata. That too issue is also addressed here.

6.1 Produced Water

The largest volume discharge from an offshore production platform is "produced water", which is water derived from the wells along with the hydrocarbons[267]. In all offshore fields, this water is separated from the desired petroleum products on the production platforms and is then discharged overboard – the volume involved amounting to as much as 3,000 tons per platform per day, though the actual amounts depend on the characteristics of the particular field and tend to increase during the life of each well. Although much of this mass is simply water, it is often at high temperature (up to 130°C at SOEP) and it contains a wide variety of dissolved and suspended contaminants, including hydrocarbons and various process chemicals added to the stream on the platform[268]. In short, it is a hot, contaminated brine, with a chemical composition quite different to that of seawater.

For SOEP, the Proponents have proposed using hydrocyclone separators and degassers on each platform (*Thebaud* and the satellites) to reduce hydrocarbon contamination in the produced water to within the regulated limit (currently 40 $mg.l^{-1}$ or nearly 40 ppm) before

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[266] The production platforms would also emit radio-frequency electromagnetic energy, from radars and communications transmitters. There is no reason to be concerned for the effects of that radiation on the natural environment while its impacts on human activities would be within the normal and well-regulated experience of the marine community.

[267] It comprises a mixture of "formation water", naturally present in the petroleum reservoir, and, in some fields, "injected water" – seawater with chemical additives that is injected into the rock formations through additional wells, to increase recovery of hydrocarbons. [For further explanation, see: Somerville, H.J., D. Bennett, J.N. Davenport, M.S. Holt, A. Lynes, A. Mahieu, B. McCourt, J.G. Parker, R.R. Stephenson, R.J. Watkinson & T.G. Wilkinson (1987) Environmental effect of produced water from North Sea oil operations. *Marine Pollution Bulletin* 18: 549-558.] The Proponents have not suggested using water injection in any of the SOEP fields but they have noted that "process water", added to the stream from the wells, and its chemical additives will also be included in the produced water discharge (*SOEP Volume 3 – EIS* pp. 3-62 to 3-63).

[268] Menzie, C.A. (1982) The environmental implications of offshore oil and gas activities. *Environmental Science and Technology* 16(8): 454A-472A; Somerville, H.J., D. Bennett, J.N. Davenport, M.S. Holt, A. Lynes, A. Mahieu, B. McCourt, J.G. Parker, R.R. Stephenson, R.J. Watkinson & T.G. Wilkinson (1987) Environmental effect of produced water from North Sea oil operations. *Marine Pollution Bulletin* 18: 549-558; GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 180 p.
SOEP Response to Panel Information Request 2.8a includes tabulated results of analyses of produced waters from the SOEP fields.

releasing it through a pipe 10 m below the sea's surface. The composition of other contaminants in SOEP produced water cannot be known for certain until it is produced but the Proponents have provided very comprehensive data on the composition of some samples[269]. They have anticipated discharging about 70 tons per well-day of this water initially, an amount which is expected to rise to more than 1,500 tons during the life of the fields – an eventual total in excess of 20,000 tons per day for the entire project, allowing for the flow rates and numbers of wells at each platform[270], or about what would be expected from the same number of platforms in the North Sea. The maximum amount of hydrocarbon discharged with this water, assuming the regulated limit was met, would be of the order 800 kg per day.

Produced water is clearly unpleasant stuff. It is likely to be instantly lethal to any organisms contacting the stream at the end of the outfall pipe, if only because of its heat and hydrocarbon content, and equally likely to still be toxic, even after considerable dilution. Hydrocarbons are known to be lethal to fish larvae, for example, at concentrations as low as 2 to 10 $\mu g.l^{-1}$ (less than 0.01 ppm) and such larvae are thought to suffer sublethal effects (which, in the ocean, can weaken an animal enough that it dies of other causes) even at 0.2 $\mu g.l^{-1}$ (less than 0.0002 ppm)[271]. However, even though the quantities of produced water released would be large, they would be discharged into a very big and turbulent ocean, where they would be rapidly dispersed[272]. Previous studies around North Sea platforms have found 1,000 times dilution of produced water within 100 m of the outfall[273] and the Proponents have claimed that modelling for the 1983 EIS suggested 1,000 fold dilution within an area less than 60 m in radius around the *Venture* platform[274]. Such dilution of a 40 ppm hydrocarbon discharge would bring it within range of the lower lethal limit for fish larvae and a further 1,000 times dilution would certainly remove all concern. The distance in which that extra dilution would occur is unsure, though almost certainly greater than the initial one. Nevertheless, produced water contamination should always be reduced to inconsequential; concentrations within, say, 500 m of the discharge point.

In the constantly-changing and ever-moving pelagic environment (unlike the static seabed) such distances are insignificant. Thus, while the produced water discharge would be very harmful to those individual biota entrained into its stream, its discharge would have negligible effects at a population level[275]. Indeed, its addition of warmth and nutrients to

[269] *SOEP Response to Panel Information Request* 2.8, Table 2.8-1.
[270] *SOEP Volume 3 – EIS* pp. 3-62 to 3-64. DFO's *Information Request* (on Section 3.3.5 of the EIS) included detailed inquiries about produced water composition. The Proponents have yet to respond to those questions.
[271] Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8.
[272] In yet another unanswered *Information Request*, concerning Section 5.2.1 of the EIS, DFO's scientists have pointed out that the Proponents have not actually offered any information on the dispersion rates of the produced water. Although not yet documented for the Panel, it seems almost certain that those rates are high.
[273] Menzie, C.A. (1982) The environmental implications of offshore oil and gas activities. *Environmental Science and Technology* 16(8): 454A-472A; Somerville, H.J., D. Bennett, J.N. Davenport, M.S. Holt, A. Lynes, A. Mahieu, B. McCourt, J.G. Parker, R.R. Stephenson, R.J. Watkinson & T.G. Wilkinson (1987) Environmental effect of produced water from North Sea oil operations. *Marine Pollution Bulletin* 18: 549-558. The Proponents cite some other relevant studies (*SOEP Volume 3 – EIS* p. 5-7).
[274] *SOEP Response to Panel Information Request* 2.8b.
[275] As the Proponents have also concluded: *SOEP Volume 3 – EIS* p. 6-15.

surface waters around Sable Island might enhance production of some species[276] – albeit at the expense of some distortion of the energy flows through natural food webs[277]. The magnitude of these effects, relative to the size of the planktonic production system on the eastern Scotian Shelf, would however be as minuscule as that of the more direct impacts of produced water.

This does not quite end the concern with produced water, however. It has been generally assumed that, once dispersed, its contaminants can be ignored. In the case of SOEP, with a mere 28 wells set near the margin of the Gulf Stream, such that their produced water would gradually be dispersed throughout the North Atlantic, this assumption may well be justified. The recent re-examination of data from surveys in the East Shetland Basin (see Section 5.2 above) has, however, raised the unexpected concern that a sufficient volume of produced water may, over time, significantly raise seabed sediment hydrocarbon loads over a wide area[278]. Thus, there is some reason to be cautious of the simplistic assumption that the contaminants in produced water simply "go away" once dispersed. A proportion of them may, in fact, accumulate in sedimentary basins which, in the case of SOEP, would likely include the floor of the Sable Gully.

Considering the nature of the physical environment around Sable Island, it seems most improbable that SOEP's 28 wells would release enough produced water to raise surrounding hydrocarbon levels sufficiently to be of concern – though the Proponents have not produced any evidence to support that conclusion and, indeed, have not addressed the issue of the long-term fates of their discharges. What is a potential concern is the possibility that more extensive petroleum production around Sable Island (initiated in response to the success of SOEP) might collectively raise sediment hydrocarbon concentrations to unacceptable levels, through the discharge of produced water. This issue should be properly addressed, and laid to rest, before large-scale offshore petroleum development on the Scotian Shelf is considered[279].

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[276] There is some evidence that the COPAN produced water discharge has had this effect: Muschenheim, D.K., T.G. Milligan & D.C. Gordon (1995) New technology and suggested methodologies for monitoring particulate wastes discharged from offshore oil and gas drilling platforms and their effects on the benthic boundary layer environment. *Canadian Technical Report of Fisheries and Aquatic Sciences* 2049: 55p.

[277] There is some reason to fear that such enrichment would tend to replace large diatoms, which can be efficiently used in the food chain leading to fish, with smaller kinds of phytoplankton: Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8.

[278] An earlier study of hydrocarbon uptake from the water column by blue mussels was interpreted as showing elevated concentrations near a production platform which did not fall to background until a distance of 10 km from the site: Somerville, H.J., D. Bennett, J.N. Davenport, M.S. Holt, A. Lynes, A. Mahieu, B. McCourt, J.G. Parker, R.R. Stephenson, R.J. Watkinson & T.G. Wilkinson (1987) Environmental effect of produced water from North Sea oil operations. *Marine Pollution Bulletin* 18: 549-558. Inspection of the published results of that work suggests that, in fact, measured concentrations actually continued to decline out to 50 km from the platform. This too may indicate a longer-range effect of produced water.

[279] In another unanswered *Information Request* (referenced to *SOEP Volume 3 – EIS* p. 5-7), DFO has similarly noted that produced water raises issues of long-term accumulation and chronic effects that should not be ignored. In doing so, they cite GESAMP's conclusion that: "Concerns about production water exist because large amounts of hydrocarbons and other toxic materials are released to the marine environment over the production life of an oil field. This evokes questions about long-term accumulations of contaminants in

6.2 Produced Sand

Some solid material, known as "produced sand", is commonly derived from petroleum wells along with the produced water. The SOEP Proponents have estimated that only minimal amounts would be produced from their wells. This produced sand would be discharged to the ocean, along with the produced water[280].

Produced sand may be composed of toxic or radio-active minerals and (despite some cleaning on the platforms) it is likely to be coated in hydrocarbons, which it will carry to the seabed faster than those dissolved in the produced water would travel – if indeed the latter travelled downwards at all. However, the quantities involved pale into insignificance when compared to the produced water and the drill cuttings. It seems most unlikely that SOEP's produced sand would have any environmental effects on Sable Island Bank beyond those already discussed for the greater discharges. For practical purposes, it can be ignored as a separate item in environmental impact assessment.

6.3 Gas Flares and Vented Gases

Production platforms have flare stacks to allow the safe burning of surplus gases. The low-temperature flares do not burn efficiently, however, resulting in a fallout of hydrocarbon residues[281]. It has been suggested that those residues may even be a significant input to surface waters. (They are one possible explanation for the observed rise in background oil levels in the East Shetland Basin: see Section 5.2.) Very little is known of the flare-combustion process, however, and its inputs to the ocean cannot be estimated[282]. The SOEP platforms, being gas producers, should in any case flare less material than an oil platform would, while the small scale of the currently-proposed development (though not necessarily of follow-up developments) should serve to minimize and effects on the marine environment.

It seems most unlikely (albeit not impossible) that this material would move into the water column in sufficient concentrations to affect the biota there. Its possible subsequent concentration on the seabed in depositional areas would supplement the similar concentration of produced water discussed above. However, the effects of flare residues on surface-living animals might be significant. Those include the "neuston" (plankton associated with the surface, such as Portuguese Men O' War), some fish (notably the Atlantic saury – an important potential fishery resource), marine mammals, which must surface to breath, and marine birds. Considering the areas likely to be affected, most of the populations concerned could not be exposed to enough flare residues for significant effects to occur. No settlement of hydrocarbons onto the surface of a sea area frequented by cetaceans, as the Sable Gully is, should be trivialized, however, and the Proponents are not justified in ignoring the flaring of gas as a pathway linking SOEP to the surrounding

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the sea and gradual ecological change of exposed marine systems" [GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 118].

[280] *SOEP Volume 3 – EIS* p. 3-8. They have also hinted that they are considering recovery of the produced sand for disposal ashore: *SOEP Response to Panel Information Request* 1.5.

[281] Flare stacks will also "burp" occasionally, depositing some unburnt condensate onto the sea's surface and gas into the atmosphere: *SOEP Volume 3 – EIS* p. 5-10.

[282] GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 104-105.

ecosystem. The impacts may be unlikely to be large but their magnitude should be given due consideration.

SOEP also proposes to vent assorted (unburnt) gases directly to the atmosphere[283]. While its effects on the atmospheric environment cannot be discussed here, this venting should not have any direct significant effect on the ocean ecosystem – the gas should disperse into the atmosphere and subsequently contact the ocean only over a very wide area and hence at low concentrations. Engine exhaust residues from the platforms and their supporting ships and aircraft would, of course, settle out onto the sea surface, adding to those from flaring. However, the quantities concerned would be no more than a tiny addition to those from existing shipping and those transported in the air from sources on the mainland. These SOEP inputs can, perhaps, be ignored.

6.4 Energy Emissions

6.4.1 Heat

Offshore petroleum platforms emit large amounts of heat energy into the environment, most of it in the form of hot produced water but also as heat from gas flares and general waste heat from the various parts of the platform and its equipment. Some effects of the high temperature of produced water are described above. Otherwise, the turbulence of air and water flowing around the platforms would be so high that this heat would be dissipated in a very short time. Its effects on the environment would be negligible.

6.4.2 Light

At night, offshore production platforms can be brightly illuminated, with aircraft and shipping warning lights, lights in working and living spaces, and at times a bright gas flare burning. Ordinarily, such light would not be considered an environmental concern of any significance and the Proponents do not appear to have considered its impacts. However, the *Thebaud* platform, which would be by far the brightest of the SOEP installations once construction was completed, would be only some 10 km off Sable Island – the sole breeding ground of the Ipswich sparrow.

As Environment Canada has pointed out in its Information Requests, Passerine birds are known to be attracted to bright lights during migrations[284]. While this remark was made with respect to lights at the gas plant on the mainland, it would also be true at sea. Indeed, concern has been raised in the past over the effects of North Sea gas flares on migratory birds[285], although nothing equivalent to the special case of the Ipswich sparrow occurs in the vicinity of the offshore petroleum fields there.

Passerines, including the Ipswich sparrow, are typically land birds. When required by their migratory routes, they will undertake lengthy migrations across the sea but usually only from one extensive land mass to another. However, if the conventional hypothesis is

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[283] *SOEP Volume 3 – EIS* p. 3-9.

[284] Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project*, p. 19. The Proponents have not offered a response to this point.

[285] de Groot, S.J. (1996) Quantitative assessment of the development of the offshore oil and gas industry in the North Sea. *ICES Journal of Marine Science* 53: 1045-1050.

correct, as the offshore sand islands of the eastern seaboard shrank following the end of the last glaciation, the breeding ground of the Ipswich sparrow was reduced to Sable Island alone. The birds are, therefore, faced with an annual migration from the Nova Scotian mainland, across 100 to 200 km of open sea, either to find a rather small island or else to perish in the ocean. That is a demanding task which may well strain a sparrow's navigational capability. "False" cues, such as a brightly lit production platform seen on a cloudy night, have at least the potential to cause many of the birds to lose their way. Even if this could only happen under unusual atmospheric conditions, occurring (at a critical migratory time) during one year in twenty, it would still be a serious negative impact of SOEP.

Taxonomic ornithologists no longer regard the Ipswich sparrow as a species but rather as a sub-species, *Passerculus sandwichensis princeps*, of the Savannah sparrow. It is, nevertheless, a discrete taxon, isolated from the nominate sub-species. As such, the loss of a significant proportion of the only breeding population would be a matter of considerable importance. Even potential impacts on such a population merit attention.

The migratory behaviour of Ipswich sparrows has been studied in some detail and it may well be possible for the Proponents to produce a reasoned argument showing that the risk of sparrows being fatally distracted by the lights of *Thebaud* is negligible. They have not yet, however, offered any evidence in support of such a position. Indeed, they have not even discussed the issue[286]. Until they do provide adequate grounds for dismissing this concern, even a moderate application of the Precautionary Principle would seem to require that no brightly-lit production platform be approved as close to Sable Island as the *Thebaud* site is.

6.4.3 Sound

Offshore production platforms are quite noisy but almost all of that sound energy is emitted into the air, where it is rapidly attenuated. With steel jacket platforms, such as those proposed for SOEP[287], the amount of noise radiated into the sea is minimal – such platforms are much quieter than their attendant supply vessels[288]. Since it is argued elsewhere in this report (see Section 1) that such ships would not have any unacceptable acoustic impacts on the marine environment, at least when close to the SOEP platform

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[286] When the Proponents were asked for their specific reasons for not listing any residual impacts on Ipswich sparrows, their only reply was (a) that they had identified no pathway linking the project to the sparrow and (b) that they had treated Sable Island, as a whole, as a VEC, while any potential impacts on the sparrow were considered as part of the assessment of impacts on the island (*SOEP Response to Ecology Action Centre Information Request* 6). The defects of using geographic areas as summary VECs for all of the ECCs that they contain are discussed elsewhere in this report (Section 2.3). In the present example of such use, it is of note that (most) Ipswich sparrows are only seasonal residents of the island and must migrate to it. This critical step in their life cycles is not included within a VEC defined by the Island's boundaries. It is also of note that the Proponents have not considered the potential pathway to sparrows acting through light emissions by their platforms. An EIA based on such superficial analysis must be suspect.

[287] At all sites except *South Venture*.

[288] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* pp. 2 & 5. Davis presents platform noise from a platform that is some 30 dB quieter than an offshore supply vessel over a range of frequencies. A difference of 30 dB corresponds to one source having an intensity 1000 times that of the other.

sites, the underwater noise from the platforms themselves seems most unlikely to have any remotely-significant effects.

6.5 Natural Radioactivity

The Proponents have submitted a consultant's report discussing the production of "Naturally Occurring Radioactive Materials" ("NORM") from offshore wells[289]. The issue arises because radioactive particles, occurring at low concentrations within the petroleum deposit, can become concentrated, as scale or sludge, when the physical conditions of temperature and pressure change at the wellhead. This is all low-level radioactivity – there is no reason to suppose that the NORM would be any more dangerous, when appropriately handled, than the radioactive materials routinely used in medical procedures, for example.

These radioactive deposits would only become environmental issues during any mid-service cleaning, when the NORM should be handled like other low-level hazardous waste, or at final decommissioning of the installations. Since the Proponents plan to dispose of their decommissioned platforms ashore[290], the details of methods to be used to handle any NORM and keep it away from the marine environment can, perhaps, be left to the regulatory agencies of 2025.

6.6 Summary

Despite its longer duration, and aside from accidental events considered elsewhere, the production phase of SOEP would have lesser impacts on the marine environment than would the earlier phases. Most of those effects would be as inconsequential as the Proponents suggest but there are three potential issues that their EIA did not even consider. Those are:

- A potentially very serious risk to the world population of Ipswich sparrows, if the light emitted by SOEP production platforms, particularly at *Thebaud*, should cause the birds to miss their destination during their annual migration to Sable Island.
- Some possibility that flare residues, supplemented by other lesser emissions, would result in a sufficient build-up of hydrocarbons on the sea surface to affect marine mammals, particularly those in the Sable Gully.
- The possibility that SOEP discharges of hydrocarbons, in produced water and/or as flare residues (perhaps supplemented by other types of hydrocarbon discharge), would result in a long-term build-up of sediment hydrocarbon loads in depositonal basins, such as the bottom of the Sable Gully. This last would be a more significant concern if SOEP should lead to other offshore hydrocarbon developments around Sable Island.

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[289] CORDaH (1997) Environmental issues with regard to Naturally Occurring Radioactive Materials (NORM) arising from oil and gas activities in the UK North Sea. *Report prepared for Mobil Oil Canada Properties Ltd.* 10p.

[290] *SOEP Volume 3 – EIS* pp. 3-28 to 3-29.

7. Other Chemical Discharges

SOEP's operations would involve the release into the marine environment of a very large number of different fluids and particulates, most of them complex mixtures of chemicals. They would include, among others:

- Waters from platform runoff, fire hoses, condensate coalescer etc. (often with some hydrocarbon or other contamination),
- Fuel and lubricant oils from minor leaks and spills,
- Fire-fighting foam,
- Well work-over fluids,
- Wellbore fluids,
- Well treatment fluids,
- Desalinator brine,
- Sanitary and food wastes from accommodation platform and ships,
- Sludge from OBM treatment,
- Hypochlorite, from platform piping systems,
- Glycols,
- Cementing discharge,
- Dusts (cement, drill mud component etc.), and
- Anti-fouling compounds from ships and platform jackets.

These must be examined as a group, if only for lack of information to support more specific considerations.

Although the SOEP EIS contained an extensive discussion of generic types of discharge, covering many of the items in the above list, the Proponents have not provided a comprehensive list of chemicals that they might release[291] and, in fairness to them, they probably cannot do so – a complete list of all the optional and potentially-necessary materials would simply be too extensive. Nor have they provided much useful information on the ecotoxicology of even the principal chemicals involved[292]. Most probably have low toxicities but some that are approved for use in the United Kingdom offshore zone, if not

[291] Despite the Panel asking for just such details of some types of discharge in its *Information Request* 2.8a.

[292] But see the tables accompanying *SOEP Response to Panel Information Request* 2.8a, which include guideline toxicity limits for a few of the chemicals involved, albeit in unstated and unexplained units.
The adequacy of this ecotoxicological information has been debated previously, the present writer suggesting that more information was required [Kenchington, T.J. (1996) Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues. *Gadus Associates report prepared for the Ecology Action Centre* Section 5] and the Proponents responding *inter alia* that they had presented the best available information (*SOEP – Responses to Scoping Process* Issue #15; *SOEP Response to Ecology Action Centre Information Request* 23). It may be that both positions are correct, if the best available information is inadequate for a proper analysis of the effects of SOEP's proposed discharges, though this writer continues to suspect that the scientific literature contains ecotoxicological information that the Proponents have not presented and yet which would assist in the assessment of their proposal.

also in Canadian waters, have 96-hour LC_{50} values below 10 ppm[293] and may thus be expected to have sub-lethal effects at very low concentrations.

All of these discharges would however be of tiny volumes, when compared to the produced water or the drill cuttings, and most would be released and dispersed into the huge volume of offshore waters, as the Proponents have pointed out[294]. Thus, most of them would probably have negligible effects on the receiving environment. However, the sub-lethal toxic effects of chemical pollutants can be complex and surprising – as was shown by the imposex phenomenon in molluscs, caused by TBT-based antifouling paints in enclosed harbour areas. Thus, while the present writer would agree with the Proponents that no significant environmental effects should be anticipated from these various discharges[295], it would not be correct to say that none will occur. Experience may yet show that one or more of these discharges has a far more severe effect than is expected.

It would not, however, be reasonable to suggest that the offshore oil industry should cease operations until all potentially-released chemicals were tested for all conceivable sub-lethal effects on every kind of marine organism. Such testing is simply not a practical option. Thus, only alternative is to allow the use of a variety of chemicals, subject to regulatory approval, and trust to the regulators to keep abreast of developing understanding of ecotoxicological effects.

[293] *SOEP Volume 3 – EIS* pp. 3-29 to 3-72; GESAMP (1993) Impact of oil and related chemicals and wastes on the marine environment. *GESAMP Reports and Studies* 50: 110-111.
[294] *SOEP Response to Panel Information Request* 2.8b.
[295] *SOEP Response to Panel Information Request* 2.8e.

8. Spills, Blowouts and Pipeline Ruptures

Aside from the regular, planned discharges during drilling and production, offshore petroleum development carries a risk of accidental losses of hydrocarbons into the marine environment; the quantities involved being potentially far larger than those routinely released. In so far as SOEP is concerned, these losses can conveniently be grouped into four classes:

- Blowouts – when the operators lose control of the natural pressure of the oil and gas in a well, such that the petroleum bursts out into the ocean or the atmosphere,
- Pipeline ruptures – involving any kind of break in a submarine pipeline[296]
- Other spills at the offshore platforms, and
- Spills associated with the tankers carrying condensate from the Point Tupper liquids plant to market (both minor spills when loading or discharging cargo and major spills associated with marine accidents, such as groundings and collisions).

Of these four, blowouts often receive the most attention, since at some fields they have the potential to release very large quantities of hydrocarbons before the well is brought under control. However, with the highly-volatile condensate to be produced by SOEP, such a prolonged spill would dissipate as fast as it was released, limiting the area affected. The relatively-sudden release of a moderate quantity from a pipeline rupture would, therefore, be more ecologically damaging. Furthermore, such a rupture is a more likely event than a blowout. Indeed, tanker spills are even more likely (comparing risks of accidents resulting in the same spilt volumes) and could be very much more severe – potentially involving far larger quantities of condensate, while having a much higher probability of occurring near shore. Thus, it is these shipping accidents, and not those directly related to offshore production, that should be of greatest concern.

8.1 Risks of Accidental Spills

The SOEP Proponents have provided estimates of the probabilities of occurrence of these various kinds of accidents, and for with various amounts of hydrocarbon released by them, based on the historic record of the offshore petroleum and the shipping industries[297]. No attempt will be made here to verify those estimates. Rather, it will simply be assumed that the Proponents' consultants have calculated them correctly from the best available data. This should not be taken as an endorsement of the values provided but simply as a convenient assumption for the purposes of this report.

The estimates of accident probabilities have been presented by the Proponents in various formats. To aid comprehension, they must be brought to a common standard, the most relevant of which seems to be the risk of an accident happening once during the proposed

[296] Ruptures to the on-land gas and liquids pipelines are not considered here.
[297] S.L. Ross Environmental Research Ltd. (1995) Blowout and spill probability assessment for the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 26 p; *SOEP Volume 3 – EIS* pp. 3-73ff, 6-20.

life of SOEP (i.e. with 28 development wells drilled and 25 years of production). Thus standardized, the Proponent's estimated risks of these accidental events are:

Event[298]	**Probability**[299]	**Chance**[300]
Offshore spill of ≥ 1 but < 50 bbl [301]	13	-
Condensate tanker spill of < 1,000 bbl	4	-
Offshore spill of ≥ 50 bbl	0.59	1 : 1.7
Any blowout during production	0.30	1: 3.3
Any blowout during drilling	0.081	1: 12
Pipeline rupture releasing ≥ 1,000 bbl	0.078	1 : 13
Condensate tanker spill of ≥ 1,000 bbl	0.071	1 : 14
Condensate tanker spill of ≥ 10,000 bbl	0.043	1 : 23
Offshore spill of ≥ 1,000 bbl	0.027	1 : 37
Pipeline rupture releasing ≥ 10,000 bbl	0.026	1 : 38
Condensate tanker spill of ≥ 150,000 bbl	0.012	1 : 83
Offshore spill of ≥ 10,000 bbl	0.0095	1 : 105
Blowout releasing ≥ 10,000 bbl	0.0052	1 : 192
Blowout releasing ≥ 150,000 bbl	0.0023	1 : 435

Understanding the true meaning of these probabilities is not as straightforward as the above table might imply. They are based on global historical records and thus do not precisely represent the real risks involved in SOEP. In particular, there have only ever been 14 offshore blowouts that released 10,000 bbl or more. Only four of those have occurred in U.S. waters, where the drilling was done under a similar regulatory and safety regime to that in Canada. Only one of those four (releasing 11,500 bbl) has occurred in the last 25 years, while the offshore petroleum industry has greatly improved its blowout-prevention equipment and procedures since the accidents of 1969-70[302]. Thus, the blowout probabilities tabulated above, may markedly over-estimate the risks associated with SOEP.

[298] Some tabulated events are special cases of others. Thus, the chance of a major blowout is contained within the chance of any blowout. However, the expected 13 offshore minor spills do not include the expected 4 minor tanker spills (i.e. a total of 17 minor spills is expected).
[299] The "probability" column usually shows the estimated probability, based on the industry's historical record, of the type of event occurring once during the lifetime of the proposed SOEP. For those events that have expected frequencies of occurrence greater than one, this column shows instead the estimated frequency of such events during the lifetime of the proposed SOEP.
[300] The "chance" column gives the same probability as in the adjacent column but in the more familiar "odds" format.
[301] "bbl" = "barrel", a unit of about 160 l. In this table, the indicated volumes released relate to condensate only and do not include released gas.
[302] S.L. Ross Environmental Research Ltd. (1995) Blowout and spill probability assessment for the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 26 p.

Conversely, the high well-head pressures expected with the SOEP wells may increase risks, relative to modern experience elsewhere[303]. Likewise, Canadian standards for tanker operational safety in the twenty-first century may well reduce the tabulated risks of related accidents very significantly.

At the same time, the tabulated volumes may be somewhat irrelevant to SOEP. Any significant rupture of the pipeline from *Thebaud* to Country Harbour would release up to 15,000 bbl of condensate (depending on the period elapsed since the last pigging operation), since the breached pipe would lose its entire contents, no matter where and how serious the rupture was[304]. Rupture of an inter-field pipeline, however, could not release more than about 100 bbl, since those pipes could never hold much condensate at any one time[305]. Thus, the actual probability of a SOEP pipeline rupture releasing 1,000 to 10,000 bbl (from a rupture of the main pipeline soon after pigging) is roughly equal to that of its releasing more than 10,000 (from a similar rupture shortly before the next pigging), rather than being twice as high, as is implied by the tabulated risks.

Similar critiques could be made of most of the other tabulated probabilities. The above figures should, therefore, be taken as indicative of the accident risks associated with SOEP, rather than as precise estimates of those risks.

It may be noted that, except for very small spills (which are rather frequent offshore), the risks of a tanker or pipeline accident are substantially greater than those of a similarly-sized blowout or offshore spill. Thus, the SOEP tanker traffic, which would be a small part of the total tanker traffic off the coasts of Nova Scotia, would be as “dangerous” (measuring “danger” only in terms of the risks of various spills) as the SOEP offshore pipelines and very much more “dangerous” than the offshore operations themselves. If the existing tanker traffic were deemed acceptably safe (which it is most certainly not by every interest

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[303] The two “any blowout” probabilities are based on figures that include so-called “shallow gas” and “water” blowouts, which would not normally be considered to carry any risk of a release of oil. In the case of the SOEP fields, however, the Proponents’ consultants have suggested that some small amount of condensate would likely be released in any blowout, including “shallow gas” and “water” ones [S.L. Ross Environmental Research Ltd. (1995) Blowout and spill probability assessment for the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* pp. 15, 23].
While no attempt is made here to verify the Proponents’ estimates of these various risks, the 1-in-12 risk of a blowout during drilling can be compared with an alternative published estimate of one blowout per 250 exploratory wells drills [Gordon, D.C. *ed.* (1988) An assessment of the possible environmental impacts of exploratory drilling on Georges Bank fishery resources. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1633, p. 22]. With 28 SOEP wells, that implies an overall chance of a blowout of 1-in-9. However, developmental drilling is known to be substantially less prone to blowouts than is exploratory drilling. Thus, the Proponents’ 1-in-12 estimate is consistent with the alternative one.

[304] This 15,000 bbl estimate was developed in the Proponents’ consultant’s report [S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* pp. 2-3] on the basis of a 225 km pipeline, 610 mm in internal diameter; that being the Proponents’ announced specifications for the *Thebaud* to Country Harbour pipe. Subsequent refinement of plans for SOEP have evidently changed this intent to a 208 km pipeline, 660 mm in diameter (*SOEP Addendum 2 – Gas Plant and Nearshore Pipeline Assessment* p. 3-3; *SOEP Response to Panel Information Request* 2.29). This will result in an 8% increase in the internal volume of the pipeline and presumably a proportionate increase in the size of any spill caused by a rupture of the pipe, which might therefore exceed 16,000 bbl of condensate.

[305] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* pp. 3-4.

group in the Province though it is currently tolerated by the public at large), then the risks of spills and blowouts from SOEP should perhaps also be considered acceptable.

It may also be noted that the risks of a significant accident, as estimated by the Proponent, are quite high. For example, combining all of the different types of accident, there is a 1-in-12 chance of a spill of 10,000 bbl or more at some time during the 25 year life of SOEP. Even if this is a substantial over-estimate and even if other equivalent risks are already accepted, this is a substantial chance of a severe accident.

8.2 Severity of Spills

8.2.1 Spill Volumes

The natures of these various accidents must, however, be placed in perspective. A barrel of SOEP condensate would physically resemble 160 litres of gasoline. Even ten litres of it, if discharged at a wharf in Halifax Harbour, would be a matter of some environmental concern, probably a clean-up effort and possibly legal action against whoever was careless enough to spill it. A spill of more than a barrel and perhaps as much as 50 bbl, which the SOEP Proponents anticipate will occur at the offshore platforms about once every two years (on average), would be cause for public outrage if it occurred in the Harbour. Offshore, this material would be spilt into a vastly larger volume of seawater, far away from people and their immediate concerns. It would also be spilt into a relatively-pristine environment and not into an already-polluted industrial harbour.

At the other extreme, 150,000 bbl of condensate would represent a very substantial spill[306]. To place it in context: Globally, only six offshore blowouts have ever released that much and only two have released substantially more – one being off Dubai, in 1973, and the other the infamous *Ixtoc 1* blowout, off Mexico in 1979, which released some 3,000,000 bbl[307]. The worst tanker accidents have exceeded all but these two blowouts: the most serious of all being the loss of the *Amoco Cadiz*, which went aground on the north coast of France in 1978, spilling 1,600,000 bbl. The *Exxon Valdez*, which caused so much damage in Alaska in 1989, produced the World's twelfth-largest tanker spill to that date and yet it comprised a "mere" 240,000 bbl[308]. Thus, the estimated 1-in-435 chance of a major blowout during SOEP and the 1-in-83 chance of an similarly-sized tanker spill are risks of very serious accidents indeed – and yet ones a good deal less severe than some of those familiar from news reports.

8.2.2 Pipeline Ruptures

A release of SOEP gas, along with its accompanying light and volatile SOEP condensate, would not, however, have the same severe effects as a spill of a typical crude oil, even one

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[306] The Proponents term it an "extremely large spill (*SOEP Volume 3 – EIS* p. 3-73).
[307] S.L. Ross Environmental Research Ltd. (1995) Blowout and spill probability assessment for the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* p. 9.
[308] Flood, P.G. (1992) Management of oil drilling in Australian waters. *Marine Pollution Bulletin* 25: 143-146. Notably, the very worst marine oil spill in history was not been the result of an accidents but rather of a deliberate act of war – the destruction of Kuwaiti oil installations in 1991 poured some 11,000,000 bbl into the Gulf. Eight years earlier, the Iran/Iraq War included rocket attacks on offshore oil platforms that led to the release of 1,900,000 bbl.

involving the same volume of spilt liquids. The Proponents have provided[309] the results of modelling some "worst-case" spills from SOEP operations. By their consultant's estimation, in the event of a pipeline rupture, the buoyant rise of the gas would generate turbulence, dispersing much of the condensate into the water column in the form of a "cloud", or "plume", of small droplets. Any liquid hydrocarbons that reached the sea surface would be expected (based on experience with COPAN condensate) to spread into a thin sheen, much as gasoline does, with a maximum thickness in a "worst-case" spill of only 0.05 mm. Such a sheen would then evaporate quickly – 50% of it being lost to the atmosphere in a matter of hours, according to the models. Such of the gaseous fraction of any spill that reached the surface would, of course, also be lost to the atmosphere[310]. That part of the surface sheen that did not evaporate would be quite rapidly dispersed into the water column, contributing to the plume of hydrocarbons, though the rate of such dispersal would depend on weather and sea state conditions – rough seas tending to disperse the condensate faster.

It should not be forgotten, however, that this is only a model-based estimate in a field where models have proven notoriously inaccurate[311]. The models used may ignore some important factors. DFO's Science Branch has suggested, for example, that the high-pressure jet escaping from a pipeline rupture would entrain water and sand. The latter could flocculate with some of the condensate and subsequently carry it down to the seabed[312]. The Proponents have made no reply to this suggestion and its quantitative importance remains unknown. The mechanism does, however, seem plausible and might result in longer-term condensate contamination of the seabed – an eventuality not considered in the SOEP EIA.

SOEP pipeline ruptures would inevitably release either a moderate (≤ 100 bbl, inter-field pipeline) or a very large[313] (≤ 15,000 bbl, *Thebaud* to Country Harbour pipeline) quantity of condensate and, in either case, they would do so over a short period – at most a few days and likely only a few hours. This rapid release of gas and condensate would produce a short-lived but rather large slick. That from a ruptured inter-field pipeline is expected to be up to some 5 km long, while according to this modelling a break in the main pipeline could produce a slick up to 7 km long. The extents of the corresponding in-water plumes are harder to estimate because they have no clearly-defined limits. The Proponents have chosen to describe the extent of the volume containing hydrocarbon concentrations above 1 ppm, which is a conservative estimate of the acutely-lethal toxicity for many organisms but far above the concentration that would be expected to have significant ecological

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[309] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 21 p.; *SOEP Volume 3 – EIS* pp.3-79ff. Unfortunately, the methods used in the modelling have not been explained. The report provided states that the methods of "Fannelop & Sjoen (1980)" and "Ditmars & Cederwall (1974)" were used [S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* p. 9] but it does not give bibliographic information to accompany these citations. In consequence, no proper evaluation of the validity of the calculated results has been possible.

[310] The effects of this hydrocarbon on the atmospheric environment are not considered here. Methane is, however, a notable "greenhouse gas".

[311] Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8.

[312] DFO Science Branch's *Information Request* Item 7.3.4.

[313] This terminology follows *SOEP Volume 3 – EIS* p. 3-73.

effects[314]. Thus calculated, the in-water plume from an inter-field pipeline break could extended as much as 8 km, whereas a major rupture in the main pipeline could produce a plume more than 40 km long and 14 km wide, which could persist for some days[315]. These figures should only be taken as indicative, with real accidents producing slicks and plumes that could be either much less, or much more, extensive.

8.2.3 Seabed Blowouts

A blowout at the seabed would resemble a pipeline rupture in its environmental effects, except that it could release almost any volume of condensate (depending on how long it took to bring the well under control) but would do so at a relatively low rate; likely not more than a few thousand barrels a day. The Proponents' modelling results[316] for various blowout scenarios therefore show smaller surface slicks (maximum 5 km long and wide) than might be seen with the worst pipeline ruptures. The accompanying in-water plumes (again delimited by the 1 ppm concentration contour) are estimated to reach as much as 17 km long by 4 km wide – a blowout at the shallow *Venture* site threatening the most extensive plume. The deeper platform sites (having more effective mixing as released gas rose from greater depths) would produce much smaller dense plumes, though the total amount of condensate mixed into the water column and its maximal reach at low, but still ecologically significant, concentrations might be greater.

These blowout-scenario modelling results are unaffected by the duration of the blowout, since the condensate is expected to be dispersed within a matter of hours. Any blowout continuing for more than a day would therefore create a steady-state slick and plume, which would disperse as fast as they were refreshed from the uncontrolled well.

8.2.4 Surface Blowouts

There is also some chance that a blowout would release its condensate at or above the sea surface, as did the *Uniacke G-72* blowout of 1984 – Canada's only offshore blowout, to date, that has released any oil into the environment[317]. That particular accident released about 1,500 bbl of a condensate very similar to the type anticipated from SOEP.

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[314] Estimates of the acute lethal toxicity to zooplankton of petroleum range from above 10 ppm to below 1 ppm [GESAMP (1993) Impact of oil and related chemical and wastes on the marine environment. *Report and Studies GESAMP* 50, p. 94), though it has also been suggested that the correct value is below 0.01 ppm, while sublethal effects, leading to death by predation or other factors, could occur at substantially lower concentrations [Howarth, R.W. (1991) Assessing the ecological effects of oil pollution from Outer Continental Shelf oil development. *American Fisheries Society Symposium* 11: 1-8]. Specific studies of Scotian Shelf condensate have shown LC_{50} values of 4 to 40 ppm for a selection of species, including sea urchins (*Strongylocentrotus droebachiensis*) and a number of freshwater- and estuarine types (*SOEP Volume 3 – EIS* p. 6-17). Once again, the concentration that would have significant ecological effects would be very much lower. The 1 ppm limit used in the Proponents' study will, therefore, seriously underestimate the spatial extent of hydrocarbon concentrations sufficient to have ecological impacts.

[315] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 21 p.

[316] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 21 p.

[317] Gordon, D.C. *ed.* (1988) An assessment of the possible environmental impacts of exploratory drilling on Georges Bank fishery resources. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1633, p. 23; S.L. Ross Environmental Research Ltd. (1995) Blowout and spill probability assessment for the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* p. 17.

Such a surface blowout would result in greater losses of gas and condensate to the atmosphere, and correspondingly less to the ocean, compared to the same well blowing out at the seabed. While all of the condensate would initially be sprayed into the air, propelled by the escaping gas, there could be a subsequent fall-out of condensate droplets onto the sea surface, down-wind of the blowout release point. With the very light condensate expected at SOEP, the Proponents' consultants have estimated that all of the liquid droplets expelled from the well would evaporate before reaching the water. They have further suggested that the maximum extent of the surface slick produced by any condensate that did not evaporate would be 1.1 km. Such a slick would be continuously dispersed into the water column, much as with that from a pipeline rupture or a seabed blowout, producing an in-water "cloud" of condensate reaching 9 km from the platform[318].

In marked contrast to these predictions, however, it has been estimated that, during the *Uniacke* blowout, only some 75% of the condensate evaporated within the first 24 hours (some of which will have fallen to the ocean surface before evaporation) and the surface slick which formed reached 10 km from the platform (though it was not continuous across that distance). The accompanying in-water hydrocarbon plume reached depths of more than 20 m, probably extended further than the surface slick (no observations were made below 21 m or further than 10 km from the well site) and has been estimated to have contained 50% of the total condensate lost from the well. However, the concentrations observed in that plume were usually less than 0.1 ppm and never more than 1.5 ppm. This blowout occurred in February and was followed by several storms, which helped to disperse the condensate[319]. Calmer weather would presumably have resulted in more extensive slicks and plumes.

The lighter condensate expected from the SOEP wells might well cause less obtrusive slicks than that from the *Uniacke* field. Thus, this contrast between model results and real-world experience may not invalidate the modelling, though the order-of-magnitude difference between the Proponents' "worst-case" result and the observed reality may be indicative of the inadequacy of the models used.

8.2.5 Tanker Spills

Despite their greater probability and severity (resulting from both the greater quantities of condensate likely to be involved and its expected rapid release) the proponent has provided little information on the consequences of condensate tanker accidents. It has been stated that each tanker will carry some 500,000 or 1,000,000 bbl of condensate per load[320]. Aside

[318] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* pp. 17-18.

[319] Martec Ltd. (1984) Report on the environmental program associated with the blowout at Shell *et al. Uniacke G-72.* Section 8 [filed with *SOEP Response to Ecology Action Centre Information Request* 4]; Gordon, D.C. *ed.* (1988) An assessment of the possible environmental impacts of exploratory drilling on Georges Bank fishery resources. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1633, p. 23.

[320] *SOEP Volume 3 – EIS* p. 3-82. In a more recent statement (*SOEP Response to Panel Information Request* 1.4a), the Proponents have suggested that that this condensate will be transported in tankers of 79,500 to 159,000 m^3 (i.e. 500,000 to 1,000,000 bbl) capacity. The larger ship would mean fewer movements and thus a lower chance of an accident – but also an increased severity should an accident occur. The same recent statement raises the possibility of butane transport by LNG barge or tanker, which would add another form of marine risk, though it would simultaneously remove the potential for rail or road accidents to butane carriers.

from the expected minor tanker-related spills (4 anticipated during the life of SOEP), which would presumably occur at the wharf when loading or discharging, tanker spills would necessarily involve marine accidents to the ships. It is unusual in such events for the entire cargo to be lost but, as a worst case, all 1,000,000 bbl could be released to the ocean. The Proponent, however, has only offered information on spills of up to 200,000 bbl, that apparently being the "worst case" event in the loss of one of the COPAN project's relatively small shuttle tankers. A slick from such a spill is said to potentially extend over 500 km^2, reaching 50 km from the spill site[321]. A spilt volume five times larger would, of course, produce a more extensive slick, though likely not one proportionately larger.

It may be supposed that much of any condensate spilt by a tanker accident would evaporate, while some would become mixed into the water column. The lack of any gas would, however, greatly slow these processes, relative to their rates in a blowout- or pipeline-rupture scenario. Thus, the slick could be expected to last longer and move further before its ultimate dispersal. How long and how far remain unknown.

8.2.6 Spill Locations

The environmental significance of each of these kinds of spills would be strongly influenced by where and when they might occur. Since SOEP is expected to continue throughout the year, each form of accident seems equally probable at any season. They differ markedly, however, in their likely locations. A blowout could only occur at one of the platform sites – the different behaviours of the condensate at each such site, as a result of its depth and the differing wellhead pressures of its wells, being touched on above. Inter-field pipeline ruptures are equally confined to the Sable Island area but a break in the *Thebaud* to Country Harbour pipeline could occur near the Island, near the mainland or in the open waters between. In the latter area, its supposed 40 km plume of dispersed hydrocarbons might be of little consequence, whereas closer to land its effects could be far more serious.

Tanker accidents, in contrast, are most often seen in the coastal approaches to the port of loading or discharge, mid-voyage tanker accidents being considerably less likely – the *Torrey Canyon, Amoco Cadiz* and *Exxon Valdez* all provided examples of this pattern. Thus, the estimated 1-in-23 predicted chance of a "very large" SOEP tanker spill represents about a 1-in-50 chance of such a spill in the Chedabucto Bay area during the 25-year life of the Project.

8.2.7 Reliability of Predictions

It is suggested above that the Proponents' estimates of the probabilities of various accidents should be taken as indicative, rather than as precise. Much the same could be said of their consultants' predictions of the outcomes of these various events. The model results are presented by their author as "worst case" outcomes[322] and indeed there are some conservative factors built in (such as an assumption of zero evaporation from surface slicks when modelling seabed blowouts and pipeline ruptures). However, and as already pointed out, there are many sources of uncertainty in any such modelling exercise and no estimates of their net effect on the resulting predictions have yet been offered. There are also many complications of wind and current dispersal of the slicks that the modelling does not appear

[321] *SOEP Volume 3 – EIS* p. 3-83.
[322] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* p. 1.

to have addressed at all, preferring an assumed steady water flow of 0.2 $m.s^{-1}$ (under half a knot) past the source of each condensate release. Thus, this work fell far short of proper modelling of spill trajectories[323]. Indeed, it did not even produce an adequate discussion of the effects of weather and season on the dispersal of any spill[324]. The potential for oceanographic convergence zones to concentrate floating condensate, after its initial dispersal, in areas where surface-associated organisms are also concentrated has not been addressed. One could continue.

Thus, while the estimations of spill probabilities and the modelling of their behaviour is valuable, it should not be taken as providing a precise description of "worst case" scenarios. Rather, it should be remembered that, should one occur, a SOEP accident might result in worse spills than has been represented by the Proponents.

8.3 Environmental Effects of Accidents

8.3.1 Offshore Accidents

It remains to consider the effects of these various potential accidents on the marine environment. Much of the released hydrocarbon from any spill, aside perhaps from a tanker accident or a pipeline rupture near Country Harbour, would be dispersed in the open sea. In the interim, any plume of condensate in the water column would likely kill much of the plankton that it contacted. Such plumes, even from worst-case blowouts and pipeline ruptures, would be rather small in spatial extent, short in duration or both. Hence, these deaths would probably have only local significance[325]. Usually, only some tiny proportion of wide-spread populations would be affected.

Under the most extreme scenarios, however, there might be a greater relative effect. If, for example, a pipeline rupture occurred near the mainland just when the eggs on a herring spawning bed near the accident site[326] were hatching, a high proportion of the larvae from that bed might be killed. However, at worst, this would only mean the loss of one year-

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[323] Though the high evaporation and dispersal rates expected with the light SOEP concentrate limit the usefulness of the types of trajectory modelling that would be used with a spill of heavy oil.

[324] Calm summer weather might be expected to promote evaporation from a surface slick but also to confine the condensate "cloud" into that part of the water column above a transient thermocline, thus causing it to spread further before dispersing to 1 ppm concentration. Calm winter weather, in contrast, would result in the least evaporation but would allow the "cloud" to disperse downwards. Rough weather might reduce evaporation but would certainly aid dispersal in the water column and should lead to substantially smaller "clouds" with concentrations above 1 ppm (though larger ones at lower concentrations). Quantifying these trends would require complex modelling, beyond the scope of this report.

[325] The only such impact that the Proponents take seriously is one on silver hake eggs and larvae. They state that a reduction in year-class strength for this species is a potential Residual Impact, in the event of a pipeline rupture (*SOEP Volume 3 – EIS* p. 6-19, Table 7.7-1). This concern over silver hake is peculiar, considering that even the Proponents' description of the marine environment in the SOEP study area notes that silver hake eggs can be found from Browns Bank to Banquereau (*SOEP Volume 3 – EIS* p. 4-140). Their spawning area is far more extensive than any SOEP spill could be and there is no reason to suppose that this species is particularly vulnerable to accidents at the SOEP installations. Of all the major commercial fish species on the Scotian Shelf, however, it is the one of least interest to the Canadian fishing industry. Perhaps it is therefore a suitable subject for a token acknowledgement of potential impact.

[326] If there is such a spawning bed. The Proponents have failed to provide any information on the distribution of herring spawning beds, or other fine-scale features of the benthic environment, near their proposed installations.

class of potential spawners from one spawning bed[327]. Since the chance of any significant pipeline rupture during the lifetime of SOEP is less than 1-in-10, the chance of a break at such a critical time and place must be hundreds to one against. Similar risks may occur with other species but few are known to share the herring's use of small, discrete spawning beds and some of those which may do so (e.g. scallops) almost certainly exchange larvae over long distances, such that the loss of offspring from one bed in one year could be made good from spawning elsewhere.

Where a condensate plume contacted the seabed, it would kill many benthic organisms. This could, of course, only occur where the seabed, within the area affected by such a plume, was shallow enough to be contacted. Unfortunately, the Proponents have offered no estimates of the depths of these plumes (which would depend on weather conditions and other factors) nor of the extents of seabed areas that might be impacted. Within those areas, however large they may be, some adult animals (e.g. clams) might be able to cease feeding for the short period of exposure to the hydrocarbons, and thus avoid direct contact with toxic material[328], since even a prolonged blowout would only generate a small plume, dispersing as fast as it was generated, which would be swept to and fro around the well site by water movements. Clean seawater should be intermittently available to an animal showing this behaviour. Other, usually smaller, types and those lacking impermeable shells would not be so fortunate, however. Thus, while a total kill would not be expected, there could be extensive damage to the benthic community for some 20 km around a seabed blowout at *Venture*, with smaller impacted areas from similar accidents elsewhere but potentially much larger ones near a shallow-water pipeline rupture.

There is some small risk that sub-lethal concentrations of condensate plume would cause tainting of fishery resources, without killing the animals[329]. Both scallops and cod develop detectable taint on exposure to oil (including Scotian Shelf condensate) at concentrations of the water-soluble fraction of that oil as low as 1 ppm or even 0.1 ppm[330]. However, these concentrations are equivalent to a total-hydrocarbon concentration (as estimated in the spill modelling discussed above) a hundred or more times higher. The maximum concentrations in a "worst-case" condensate plume from a SOEP accident are not expected to be even close to the levels that would cause tainting[331]. Thus, while it might be necessary for the fishing

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[327] Herring may have some tendency to return to their natal spawning bed as adults, though there is no conclusive proof. Even if they did, a major reduction in one year-class would not have an equally-severe effect on the local spawning unit as a whole unless intense fishing pressure had depleted the other year-classes – a possible but extreme situation.

[328] This ability should not be relied upon, however. According to unpublished research undertaken for Environment Canada, scallops are narcotized by oiled water and thus are unable to evade it [Carter, J.A. (1989) Variables which affect the potential for taininting in resource species. *Unpublished paper presented to PERD workshop, Ottawa, May 1989*]. Whether or not this would occur at the hydrocarbon concentrations expected in condensate "clouds" from a worst-case accident at a SOEP installation remains unclear, since the original report on this research is not available.

[329] The SOEP Proponents do not appear to have considered this possibility.

[330] Carter, J.A. & R. Ernst (1989) Tainting in sea scallops (*Placopecten magellanicus*) exposed to the water-soluble fraction of crude oil and natural gas condensate. *Unpublished paper presented Calgary, June 1989*; Ernst, R.J., W.M.N. Ratnayake, T.E. Farquharson, R.G. Ackman, W.G. Tidmarsh & J.A. Carter (1989) Tainting of Atlantic cod (*Gadus morhua*) by petroleum hydrocarbons. *In:* F.R. Engelhardt, J.P. Ray & A.H. Gillam (eds.) *Drilling Wastes.* Elsevier, London & New York: 827-839.

[331] S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* 21 p.

industry to refrain from fishing in affected areas, to avoid market perception of a possible taint, that should be all.

Offshore, surface condensate slicks would have some effect on very-near-surface plankton ("neuston")[332] and fish (e.g. Atlantic saury). However, their greater effect would be on air-breathing animals –birds and marine mammals– which are obliged to pass through the surface frequently. The actual effect would be highly time- and site-specific, reflecting the irregular distribution of such animals. It is certainly possible that birds could be oiled[333], though the species and numbers would depend on just where and when the slick appeared. It is also possible that some marine mammals would be oiled, particularly by a slick in the vicinity of Sable Island[334]. Whether contact with the condensate would be fatal for a seal or cetacean is unclear but the possibility remains of significant disruption, particularly to the feeding of the breeding populations of seals on Sable Island and that of their pups.

8.3.2 Inshore Accidents

Surface slicks from a blowout should not reach Sable Island, if the Proponents' estimates are correct, though one from a rupture of the main pipeline near *Thebaud* might[335]. A similar rupture near the mainland could produce a surface slick that would come ashore, depending on wind direction, anywhere from Fisherman's Harbour to Country Island, or in to the outer reaches of Country Harbour and Isaac's Harbour – again if the modelling results are to be trusted. Although they have provided extensive tabulated data on the birds that might contact such a slick[336] they have said little about its environmental effects. Those, while limited in spatial extent and probably also in duration, considering the very light condensate involved, would not be pretty. They would probably include extensive death of intertidal organisms in the affected areas and a substantial number of bird deaths. If an inshore pipeline rupture occurred during the wrong season, substantial numbers of

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[332] On a calm day inshore, this could include lobster larvae.

[333] The Proponents have acknowledged the risk to marine birds from these slicks but dismissed that to coastal waterfowl and shorebirds, on the grounds that surface slicks should not reach Sable Island (*SOEP Volume 3 – EIS* p. 6-19). This ignores the risk to such birds in the event of a pipeline rupture near the mainland, though that possibility is later accepted as a residual impact (*SOEP Volume 3 – EIS* Table 7.7-1). Murres were killed by the *Uniacke* blowout: Martec Ltd. (1984) Report on the environmental program associated with the blowout at Shell *et al. Uniacke G-72*. Section 8 [filed with *SOEP Response to Ecology Action Centre Information Request* 4].

[334] An impact that the Proponents have dismissed as "negligible" (*SOEP Volume 3 – EIS* p. 6-18) and ignored in its summary of impacts (*SOEP Volume 3 – EIS* Table 7.7-1).

[335] The Proponents have stated (*SOEP Volume 3 – EIS* p. 7.4) that "Condensate is not expected to reach Sable Island even in a worst case scenario" but that is apparently intended to apply only to blowout releases. Even then, it would be incorrect if taken to include the condensate "clouds" dispersed in the water column. The *Thebaud* site is about 10 km from the island and the pipeline corridor from there to Country Harbour reaches to within perhaps 5 km of the West Spit (*SOEP Volume 3 – EIS* Fig. 1.3-1). The Proponents' consultant's "worst case" estimate of surface slick length from a pipeline rupture is 6.9 km (S.L. Ross Environmental Research Ltd. (1995) The behaviour and fate of gas and condensate spills from the Sable Offshore Energy Project. *Report to Mobil Oil Canada Properties* p. 16) but a break in the pipe larger than 100 mm or an easterly tidal stream faster than half a knot could readily extend a slick to sufficient length to contact the island, if the rupture were close to *Thebaud*. Indeed, the Proponents appear to accept this possibility elsewhere in their documentation, since they rate the likelihood of Sable Island's shore being fouled by condensate as "very low", rather than non-existent (*SOEP Volume 3 – EIS* Table 7.7-1).

[336] *SOEP Response to Panel Information Request* 2.22.

(threatened) roseate terns, from the colony on Country Island, or conversely of (endangered) harlequin ducks, besides larger numbers of more common species.

Condensate plumes in the water column, with acutely-lethal hydrocarbon concentrations, could be much more extensive – extending over wide areas of seabed around Sable Island for a number of weeks, in the case of a severe blowout, or over a far larger area for a number of days, in the case of a major pipeline rupture. In the case of a pipeline break near the mainland, the plume might well reach as far as Canso or Sheet Harbour (some 50 km east and 70 km west of the pipeline, respectively) with acutely-lethal concentrations – killing a substantial proportion of the shallow sub-tidal and inter-tidal benthos throughout that zone. Depending on weather and other conditions, as well as the precision of the modelling, such effects could reach substantially further, while sub-lethal but ecologically-significant effects might extend to either Cape Breton or else well down the South Shore of Nova Scotia.

The slick resulting from a condensate tanker accident could be far more damaging than that from a pipeline rupture, since it would likely release a greater quantity of condensate over a shorter time, without the dispersive effects of the expanding gas. It would also almost certainly do so close to the coast and specifically in Chedabucto Bay. The resulting damage would not be as severe as that from a spill of an equal volume of crude oil or refined fuel oil, such as was seen in Alaska when the *Exxon Valdez* spilt its cargo, but it could still be very damaging indeed to the area affected, to the natural biota there and to human interests. The Proponents have not considered these impacts at all in their EIS or subsequent filings and thus no adequate base of information on the animals likely to be affect is available. It is known that there are cetaceans, seals and seabirds in Chedabucto Bay at various seasons, as well as lobster and other fisheries, plus aquaculture operations. All could be very seriously affected.

The *Arrow*, which was wrecked on Cerberus Rock in Chedabucto Bay in February 1970, spilt only 9,500 t of Bunker ‘C’ fuel oil but that was devastating enough to the local marine environment – contaminating much of the shoreline from Isle Madame to Port Hawkesbury and thence southeast to beyond Canso, as well as fouling the beaches of Sable Island 200 km south and spreading smaller amounts of oil westward almost to Halifax[337]. The SOEP condensate tankers, in contrast, could potentially spill twenty times as much, albeit of a much lighter oil, in exactly the same place[338].

A slick from a spill near the mainland could have additional impacts, besides those on the natural environment and on fishery resources. One such would be fouling of fishing gear[339]. The Proponents have judged this to be a “minor or insignificant” impact[340], which perhaps it would be. Certainly, condensate would evaporate off fouled gear in time, unlike the typical crude oils involved in other types of spills. Fouling would still involve the affected fishermen in considerable inconvenience and some loss of income, which would require compensation. Another possible impact would be one on the developing eco-tourism industry along the Eastern Shore of Nova Scotia. While no condensate spill would be extensive enough to prevent tourism operations along the shore (even those involving

[337] Forrester, W.D. (1971) Distribution of suspended oil particles following the grounding of the tanker Arrow. *Journal of Marine Research* 29: 151-170.
[338] This is another potential impact that the SOEP Proponents have not acknowledged.
[339] A potential problem offshore too, though the greater density of gear near the coast would make it a more serious problem there.
[340] *SOEP Volume 3 – EIS* Table 7.7-1.

kayaking expeditions), the consumer's knowledge of a pollution event would impact on the reputation of the industry sector. This too might require compensatory payments in the event of a pipeline rupture[341].

8.4 Cumulative Impacts

The incidence of hydrocarbon spills into the waters off Nova Scotia is too low for any resulting from SOEP activities to interact with other such events. Nor are other developments likely that would alter the impacts of any SOEP spills. However, it is expected that SOEP's success, if any, would lead to additional natural gas development on the Scotian Shelf. It should, therefore, be noted that the probabilities of accidents listed above are those for the 25-year and 28-well SOEP proposal. More wells, with more gas brought ashore, would of course increase the chances that each kind of accident would occur at least once during the entire period of gas production off the coast of Nova Scotia.

8.5 Summary

Accidental spills from SOEP operations and installations would involve some impact on the marine environment and, should a major spill occur, that impact could be very severe. The expected minor spills from the offshore platforms and at the Point Tupper tanker terminal would be messy and damaging but not beyond the norm for the shipping community. Even a major pipeline break mid-way between Sable Island and the mainland would not have overwhelming consequences, unless by the unluckiest chance. A significant blowout or pipeline rupture near Sable Island, or such a rupture near Country Harbour, would however be very damaging to shallow-water benthos, to sea- and shore-birds, possibly to marine mammals, maybe to sub-populations of planktonic organisms and perhaps to fishermen. A significant condensate tanker spill in Chedabucto Bay would be even more damaging – a major ecological disaster by any reasonable standard.

However, such impacts must be seen in perspective. The primary risk of a major accident would be either the (estimated) 1-in-23 chance of a spill of over 10,000 bbl from a condensate tanker or the 1-in-83 chance of a spill of over 150,000 bbl from such a ship during the 25 years of SOEP. Pipeline risks are of the same order (estimated at 1-in-38 of a break spilling over 10,000 bbl) but other major accidents are substantially less likely. Yet, these are the risks associated with all tanker operations, including those that bring crude oil to Nova Scotia's refineries, fuel to the Tuft's Cove generating station and refined oils to distribution centres all around the coast of the Province. Moreover, a spill of the volatile SOEP condensate would be much less damaging to the marine environment than one of either crude oil or fuel oil, yet the risk of the latter is accepted on a daily basis.

[341] The Proponents do not recognize this potential impact. Indeed, the only shoreline that they seem to have considered might be vulnerable to contact with a slick is that of Sable Island – a possibility that they dismiss as being "minor or insignificant" and anyway of a "very low" probability of occurrence (*SOEP Volume 3 – EIS* Table 7.7-1).

9. Seismic Surveys

9.1 Sound in the Sea

While SOEP support ships, aircraft and the offshore platforms themselves would emit some underwater sound, by far the loudest noises generated by the offshore petroleum industry are those produced by seismic survey equipment. This equipment is designed to create very loud noises, the echoes of which off geological strata deep within the seabed are used to locate likely places for drilling wells. The sounds were at one time made by explosives, which could kill fish at a range of some hundreds of metres, but the almost universal seismic equipment now used offshore is an array of "airguns", which is much less destructive[342].

Most of the survey work required for the SOEP development has already been completed, though the Proponents have stated that some more seismic work will be done, specifically a 3-dimensional survey of the *North Triumph* and *Alma* fields that is scheduled for April 1997[343]. Moreover, they have also stated that "there is every prospect" of additional development of Sable Basin resources, beyond the SOEP proposal, if this project proves the economic viability of the region's natural gas[344]. The effects of seismic exploration in support of that additional development must, therefore, be considered as indirect impacts of SOEP. The Proponents have addressed the environmental effects of seismic surveys in their EIS[345] but more particularly in the form of a consultant's report[346], provided in lieu of a response to the Panel's *Information Request* 4.3.

In assessing the environmental effects of underwater sound, the first task is to determine at what range that sound would be audible to marine animals. In so far as fish and marine mammals are concerned, this does not often require knowledge of their hearing ability, since specific sounds are most often obscured by general "background" (or "ambient") noise before they drop to inaudible levels. Thus, the task requires study of the source level of the sound, of the propagation characteristics of sound in the area of interest and of the intensity of the background noise. Only if it can be shown that the sound will be audible in an area of particular concern is it necessary to consider what effect the sound will have on marine biota there.

Davis' report includes a source level spectrum for a seismic survey airgun which reached peak sound pressure at a frequency of about 50 Hz – a fairly typical value for the current generation of survey equipment[347]. The peak source level presented, around 210 dB re 1 µPa at 1 m range, was however calculated for a 1/3 octave bandwidth. Converting to the more conventional 1 Hz-bandwidth spectrum levels would reduce the quoted source level to about 198 dB. This too seems to be typical of, or perhaps a little below, the sound

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[342] Chamberlain, D.W. (1991) Effects of nonexplosive seismic energy releases on fish. *American Fisheries Society Symposium* 11: 22-25.
[343] *SOEP Volume 3 – EIS* p. 6-12; *SOEP Response to Panel Information Request* 2.23a.
[344] *SOEP Additional Written Evidence* p. 5.
[345] *SOEP Volume 3 – EIS* section 6.3.1.2, pp. 6-10ff.
[346] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* 21 p.
[347] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* Fig. 4.

levels emitted horizontally by survey airguns[348]. For present discussion, a source level of 200 dB can be taken as typical, rather than an extreme upper limit.

The best available description of ambient noise levels in the SOEP study area was prepared by the Defence Research Establishment Atlantic from 14 years of monitoring[349]. At a frequency of 45 Hz, this shows a sound level of 90 dB re 1 μPa.Hz^{-1} as an annual average for the Scotian Shelf, with the summer and winter levels being 89 and 94 dB respectively. This suggests that, back-calculated to 1 metre from the source, the intensity of the airgun's sound would exceed the ambient level by around 110 dB, depending on the season.

In simple theory, low-frequency underwater sound waves spread spherically and so the intensity of a sound falls off as 20.log R dB, where R is the ratio of two distances from the source. This theory is likely quite accurate for the SOEP area when considering the propagation of sounds close to their sources. At the great distances over which survey airguns could be heard, however, it is necessary to consider attenuation (loss of energy to the water and a minor effect at frequencies as low as 50 Hz), energy losses to the surface and the seabed (which are site-specific and weather-dependent) and, most importantly, the effects of sound channelling. On the Scotian Shelf, the temperatures and salinities of the various water layers tend to trap sound waves, reducing their vertical spreading and thus changing the decrease in intensity over distance to only about 10.log R dB. It is the seasonal increase in the strength of this channelling effect which, in winter, allows for longer-distance transmission of ship noise, thus raising ambient noise levels on the Scotian Shelf above their summer values[350].

Davis[351] has presented the results from a model incorporating all of these factors, as they apply on the Scotian Shelf, the results of which suggest that a 50 Hz sound would decrease in intensity by 100 dB when transmitted over 50 km, making that an approximate upper limit to the distance at which a seismic survey could be heard. This compares with an equivalent range of 100 km, assuming the simple 20.log R model or an effectively unlimited distance[352] under the 10.log R model that is more nearly applicable to the Scotian Shelf. Indeed, an unpublished study of sound propagation on the Scotian Shelf, cited by Davis, shows a measured loss over 100 km of only some 65 dB for a 40 Hz sound[353], rather than the 100 dB over 50 km calculated by the model. This is not to say that Davis'

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[348] Seismic survey airguns are designed to emit high levels of sound vertically downwards, their lateral emission levels being much lower. The airgun used in a recent experiment in the Barents Sea proved to have a peak spectrum source level of nearly 210 dB re 1 μHz.Hz^{-1} at 1 m range and a frequency around 45 Hz. This was measured at about 65° off the vertical acoustic axis and thus probably over-estimated the level of sound emitted horizontally: Engås, A., S. Løkkeborg, E. Ona & A.V. Soldal (1996) Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2238-2249.

[349] Zakarauskas, P., D.M.F. Chapman & P.R. Staal (1990) Underwater acoustic ambient noise levels on the eastern Canadian continental shelf. *Journal of the Acoustical Society of America* 87: 2064-2071.

[350] Zakarauskas, P., D.M.F. Chapman & P.R. Staal (1990) Underwater acoustic ambient noise levels on the eastern Canadian continental shelf. *Journal of the Acoustical Society of America* 87: 2064-2071.

[351] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* p. 9, Fig. 6.

[352] Calculated as 10,000,000 km.

[353] Davis, R.A. (1997) Potential effects on marine mammals of underwater noise from the Sable Offshore Energy Project. *LGL Ltd. report to CEF Consultants Ltd.* Fig. 5.

conclusion is wrong but the possibility of much more efficient long-range propagation of airgun sounds, making them audible over many tens of kilometres, must be borne in mind.

9.2 Environmental Effects

The effects of artificial underwater sound on fish and marine mammals are incompletely understood. An airgun "shot" should not directly kill or injure a fish unless it was very close to the airgun indeed. In one experiment, egg, larval and juvenile cod one metre from an airgun suffered, at most, only temporary effects[354]. Tests with other species also suggest that such direct and immediate effects only occur within a few metres of an airgun[355] – while most free-swimming fish may be expected to avoid the seismic survey ship and its towed equipment by more than that distance. Thus, direct deaths caused by seismic "shooting" should be negligible or even non-existent.

However, it is known that some fish will react markedly to sounds 20 dB or more above the ambient level[356]. Such a level, requiring a decrease of about 90 dB from the source level at 1 metre range, would be reached anywhere between 30 km (by Davis' figures) and some hundreds of kilometres from an airgun operated on the Scotian Shelf. Any seismic survey in this area must, therefore, have at least a short-term effect on the behaviour of fish over a wide area.

This behavioural effect can be quite marked. Commercial fishermen have long complained about reductions in their catch rates when a seismic survey ship is operating in the vicinity. These complaints have recently led to a number of research studies[357]. The earlier ones mostly only looked at short ranges and very high sound intensities. They showed that the fish would only suffer physiological damage at insignificantly-short ranges but they were not able to provide much information on behavioural effects. The most recent study, in

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[354] Dalen, J. & G.M. Knutsen (1986) Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. *unpublished paper presented to ICA Associated Symposium on Underwater Acoustics (16-18 July 1986, Halifax, Nova Scotia)*. The less-often-used "watergun" survey equipment proved to be substantially more destructive, causing 90% mortality of juvenile cod at a range of 2 m. Waterguns produce a negative-pressure primary pulse which causes over-expansion of the fish's gas-filled swimbladder, whereas the positive-pressure primary pulse from an airgun causes a harmless compression of that soft-walled space.

[355] Chamberlain, D.W. (1991) Effects of nonexplosive seismic energy releases on fish. *American Fisheries Society Symposium* 11: 22-25.

[356] Hawkins, A.D. (1993) Underwater sound and fish behaviour. *In:* T.J. Pitcher (ed.) *The Behaviour of Teleost Fishes.* (2nd edition) Johns Hopkins University Press, Baltimore: 114-151.

[357] Dalen, J. & G.M. Knutsen (1986) Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. *unpublished paper presented to ICA Associated Symposium on Underwater Acoustics (16-18 July 1986, Halifax, Nova Scotia)*; Chamberlain, D.W. (1991) Effects of nonexplosive seismic energy releases on fish. *American Fisheries Society Symposium* 11: 22-25; Pearson, W.H., J.R. Skalski & C.I. Malme (1992) Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1343-1356; Skalski, J.R., W.H. Pearson & C.I. Malme (1992) Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1357-1365; Løkkeborg, S. & A.V. Soldal (1993) The influence of seismic exploration with airguns on cod (*Gadus morhua*) behaviour and catch rates. *ICES Marine Science Symposium* 196: 62-67; Engås, A., S. Løkkeborg, E. Ona & A.V. Soldal (1996) Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2238-2249.

contrast looked at the effects of a five-day airgun survey on a cod and haddock ground in the Barents Sea, using a combination of scientific-survey and commercial-fishing techniques. The fish survey work extended across a circle 40 nautical miles in diameter (a maximum range of some 33 km from the airgun survey area) and continued until five days after the seismic work was completed. It had been supposed that this study would extend far enough and long enough to delimit the area and time affected by the airgun's sounds. In the event, however, acoustic estimates of fish density fell by 45% immediately on commencement of the seismic work and across almost the entire study area. Those estimates continued to fall, and the area affected continued to increase, even after the airgun shooting was concluded. Cod catch rates with commercial-type fishing gear fell as much as 69% within the shooting area and some 50% out to the study boundary. They did not increase in the five days after shooting ended. Haddock catch rates were even more severely affected. The catch rates on longlines did not, however, fall quite so far and did show some recovery before the end of the study[358].

It may therefore be expected that a seismic survey on the Scotian Shelf will cause many fish to move some tens of kilometres away from the airgun, substantially depressing commercial catch rates in the vicinity for at least several days during and after the survey, though it should not injure or kill any fish (except those very few that approach within a few metres of the airgun). This degree of disturbance could be very significant to fishermen working near the survey area. Indeed, if the fish were forced away from their spawning ground, or even a prime feeding area, there could be some significant loss to the resource. Seismic surveys are not innocuous to the fish or the fisheries.

The effects of these sounds on marine mammals are even less well known – essentially unknown in the case of the grey and harbour seals of Sable Island[359]. Whales, primarily bowheads, have been reported in the scientific literature as showing reactions of various kinds to seismic surveys at distances of 5 to 10 km, while there is even a report of sperm whales altering their behaviour in response to the sound of a survey some hundreds of kilometres away. One recent study has suggested that dolphins show a similar tendency to avoid seismic vessels, though some individuals were observed within 2 km of the airguns[360]. Given the cylindrical-spreading typical of underwater sounds on the Scotian Shelf, the distances at which any given intensity of sound would be received will tend to be greater than in other parts of the world ocean. Thus, whale behaviour in the Sable Gully might be affected by seismic operations some tens of kilometres away[361]. It does seem, however, that while such surveys disturb (and perhaps even cause pain to) cetaceans,

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[358] Engås, A., S. Løkkeborg, E. Ona & A.V. Soldal (1996) Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2238-2249.

[359] Dr. W.T. Stobo has raised the possibility that the declining population of harbour seals on Sable Island might be affected by SOEP-generated noise since this species mates in the water and disturbance could disrupt their display and mating (DFO Science Branch's *Information Request* Item 6.3.4). The Proponents have not responded to this point.

[360] Gordon J. & A. Moscrop (1996) Underwater noise pollution and its significance for whales and dolphins. *In:* M.P. Simmonds & J. Hutchinson (*eds.*) *The Conservation of Whales and Dolphins: Science and practice.* Wiley, Chichester: p. 305; Goold, J.C. (1996) Acoustic assessment of populations of common dolphin *Delphinus delphis* in conjunction with seismic surveying. *Journal of the Marine Biological Association* 76: 811-820.

[361] The Proponents' suggestion that avoidance behaviour by whales in the Sable Gully would only occur if a seismic survey vessel passed within 10 km (*SOEP Response to Word Wildlife Fund Canada Information Request* 4) may be correct but could prove to be overly optimistic.

possibly reducing their feeding opportunities or exposing juveniles to predation, they do not directly injure or kill at any reasonable range

To the degree that such surveys are "of short duration"[362], the effects on cetaceans may indeed be as insignificant as the Proponents' EIS states. However, to the degree that the Sable Gully is a valuable and sensitive area for marine mammals, it may be deemed unacceptable for even minor disturbance to be caused to the animals there.

9.3 Summary

Airgun seismic surveys around Sable Island, both those required to complete SOEP's project planning and those ahead of other offshore petroleum developments encouraged by SOEP's progress would, therefore, have pronounced effects on the marine environment. Those effects would not include much death or injury to marine animals but would involve considerable behavioural disturbance, possibly leading to lost production and growth. These effects can be expected to extend tens of kilometres from the survey area, such that animals in the Sable Gully could be affected by surveys anywhere in the SOEP area around Sable Island except, perhaps, *Alma*.. The greatest effect might, however, be on catch rates in the commercial finfish fisheries – though they could potentially be mitigated by suitable scheduling of the surveys, communication among the parties concerned and, ultimately, compensation.

[362] *SOEP Volume 3 – EIS* p. 6-13.

10. Crossing the Strait of Canso

Aside from all of its installations and operations around Sable Island, extending from there to Country Harbour and on shore, SOEP also involves a marine pipeline crossing of the Strait of Canso, by the liquids pipeline in the vicinity of Point Tupper. The Strait is an unusual area, which poses environmental problems not encountered elsewhere by SOEP. Those problems have been incompletely considered by the Proponents, who have yet to propose any specific solutions to them. In consequence, they are, in effect, asking the Panel for blanket approval to lay a pipeline across the Strait in whatever way suits their requirements.

10.1 The Strait Environment

10.1.1 The Physico-Chemical Environment

The Proponents have provided a reasonably detailed account of the physical environment of the Strait, from the Causeway to Bear Head and Melford Point, where it begins to open into Chedabucto Bay[363]. They have not provided any information on the Bay itself, presumably since they consider that the effects of laying a pipeline at Point Tupper could not extend beyond Melford Point – a debatable assumption.

To summarize the information provided by the Proponents and expand on a few key points: the Strait of Canso is a deep (64 m maximum), narrow, steep-sided, flat-bottomed channel which previously linked the southern Gulf of St. Lawrence to Chedabucto Bay and the Atlantic. As a narrow link between two such large water bodies, it was swept by fast tidal streams and meterologically-driven water flows – the combination reaching speeds as high as 5 knots[364]. With such strong flows, much of the Strait's seabed was composed of coarse sediments. However, construction of the Canso Causeway, which was completed in 1954, essentially closed off the connection between the Gulf and the Atlantic, dividing the Strait into two very different basins, while fundamentally changing the environment in each of them.

Of the two, the area on the Atlantic side of the Causeway is the only one of concern here. It is some 18 km long and under 2 km wide, with an average depth of about 45 m[365]. Being closed at its inner end, no tidal streams flow through it, while its great depth and narrow shape means that, even at spring tides (maximum tidal range about 2 m), the local tidal streams are weak: negligible at the Causeway itself and apparently only about a tenth of a knot elsewhere[366]. There is no substantial freshwater inflow to the Strait and hence no marked estuarine[367] circulation occurs either. The principal water flows are, therefore, either meterologically-driven (by wind friction on the surface layer or by changing air pressures acting on the surface) or else a result of "seiching" – gravity-driven adjustments to the removal of a meteorological force (e.g. a flow back towards the Causeway when a strong northwest wind is followed by calm). Such flows have been recorded at as much as

[363] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 5-46 to 5-71.
[364] Vilks, G., C.T. Schafer & D.A. Walker (1975) The influence of a causeway on oceanography and foraminifera in the Strait of Canso, Nova Scotia. *Canadian Journal of Earth Science* 12: 2086-2102.
[365] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-47.
[366] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-51.
[367] Seaward and brackish on the surface, landward and fully saline at depth.

1.2 knots and estimates of extreme conditions suggest that they may approach 2 knots once every 25 years[368].

In all cases, these water flows must be along the axis of the Strait – both the shape of the basin and that of the surrounding hills (which strongly influence the local wind patterns[369]) ensure that across-Strait movements will be far smaller. The flows should occur throughout the depth of the water column, though maximal sub-surface velocities may be lower than those at the surface, if only because the wind will sometimes move a layer 5 or 10 m deep while the compensatory movement in the opposite direction may move a similar volume in a layer 30 or 40 m deep. Close to the seabed, friction will serve to reduce these movements even more.

In winter, the Strait is filled with a more-or-less homogenous water mass of around 1°C and 30 ppt salinity, only the extreme surface being somewhat diluted by local run-off. Under such conditions, water could be stirred from surface to bottom and *vice versa*, though the depth of the Strait and its lack of large waves suggest that such mixing would be minimal. In summer, an intense thermocline can form in the top 10 m of the water column, such that conditions on the bottom are little changed from those in the winter, while the extreme surface is warmed to above 20°C[370]. Such a thermocline would largely isolate surface waters from those at depth.

In winter, north-westerly winds will drive the surface water out of the Strait, causing upwelling near the Causeway and an inward flow at depth. South-westerly winds would cause the reverse movements. These upwellings and downwellings would lead to substantial exchange of surface and bottom waters. In summer, the different densities of the warm surface and cold bottom layers would tend to resist such flows, though upwelling of cool water near the Causeway has been observed[371], which must have been accompanied by an inward flow near the bottom. Indeed, in August 1973, when a detailed oceanographic section was performed, that inward flow seems to have been confined to the bottom few metres of the water column and, having only a small cross-section to pass through, must have been correspondingly fast. Although not yet observed, it is likely that south-westerly winds in summer have the reverse effect, driving a significant, seaward flow along the bottom of the Strait.

Construction of the Canso Causeway also served to exclude (almost) all ice from the part of the Strait of present concern. With its depth and natural shelter from tides and waves, this area therefore grew into a significant port, with substantial industrial development along its shores – beginning with the Nova Scotia Forest Industries pulp plant in 1961 and the Canadian General Electric heavy water plant, which commenced operations in 1970[372]. One consequence of this development has been the discharge of large quantities of

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368 *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-53.

369 North-westerly and south-easterly winds experience both "channelling", or deflection along the channel, and "funnelling", or increased wind speed as the air moves through the narrow opening, in the Strait of Canso [Environment Canada (1992) *Scotia/Fundy Marine Weather Guide* p. 20].

370 Vilks, G., C.T. Schafer & D.A. Walker (1975) The influence of a causeway on oceanography and foraminifera in the Strait of Canso, Nova Scotia. *Canadian Journal of Earth Science* 12: 2086-2102.

371 Vilks, G., C.T. Schafer & D.A. Walker (1975) The influence of a causeway on oceanography and foraminifera in the Strait of Canso, Nova Scotia. *Canadian Journal of Earth Science* 12: 2086-2102; *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Fig. 5.5-7.

372 Maritime Resource Management Service, Council of Maritime Premiers (1975) *Strait of Canso Natural Environment Inventory: Fish and wildlife resources*, 18 p.

pollutants into the Strait, where the generally-slow currents have allowed their deposition, coating the naturally-coarse sediments of the Strait's bed with a layer of much finer material. These pollutants have included organic-rich material from the pulp plant. With the lack of water movement, breakdown of these organics has led to decreases in oxygen levels in the sediments, modifying the chemical states, and hence the fates, of other contaminants[373].

By the 1970s, sediment samples at some sites in the area where the SOEP liquids pipeline crossing is likely to be constructed were showing concentrations of mercury, lead and zinc that would now be classed, by Environment Canada, as unacceptably high for material to be dumped offshore. More extensive studies in the 1980s failed to find the high concentrations of mercury but did confirm the excessive amounts of lead and zinc in some areas, while adding cadmium and copper to the list. Moreover, PCBs were found at concentrations as high as 1395 ppm – some 14,000 times higher than would be acceptable for open-sea disposal. Even the Strait-wide average PCB load was 244 ppm[374]. Most recently, dioxins and furans have been reported from the Point Tupper area, with total concentrations of the order of a few parts per billion[375].

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[373] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-61.

[374] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 5-61 to 5-66. There is an inconsistency in the information on PCB concentrations provided by the Proponents. They once state and once imply that Environment Canada's ocean dumping guidelines limit PCB concentrations in material dumped in open water to 100 $\mu g.kg^{-1}$ (i.e. 0.1 $mg.kg^{-1}$: *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-65 & Table 5.5-17). They also state that the PCB concentrations found in the most recent study off Point Tupper were up to 1250 $mg.kg^{-1}$ (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Table 5.5-21). Yet they state that those concentrations were "6 to 10 times higher than guideline" (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-66), when their other statements show that they were, in fact, up to 12,500 times the limiting level set by the ocean dumping guidelines.
There are further inconsistencies in this section of the Proponents' submission. *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Table 5.5-21 gives the range of observed PCB concentrations as 656-1250 $mg.kg^{-1}$, yet the average concentration is tabulated as 1311.5 $mg.kg^{-1}$. Clearly, no average can fall outside the observed range in this way and there must be some error – though probably only a typographic one. Similarly, the Proponents state that the summed concentration of PAHs in these same samples from off Point Tupper was less than the present guideline of 2.5 $mg.kg^{-1}$, whereas their own table shows it as <u>averaging</u> 3.4 $mg.kg^{-1}$ (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-66 & Table 5.5-22).

[375] *SOEP Responses to Scoping Process*, p. 33. The Proponents' presentation of this dioxin and furan information, besides having appeared disturbingly late in their corridor-selection process, seems rather misleading. They state that these extremely-hazardous contaminants are found in an area "extending from approximately Point Tupper to Pebbles Point" which is north of their pipeline corridor. Not only does Pebbles Point lie <u>within</u> their corridor for the Strait crossing (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Appendix A, Constraint Map #4), but the source they cited [Trudel, L. (1991) Dioxins and furans in bottom sediments near the 47 Canadian pulp and paper mills using chlorine bleaching. *Unpublished report, Water Quality Branch, Inland Water Directorate, Environment Canada* Fig. 7a] appears to provide data from only a single station in the Strait of Canso, located just off the Stora Forest Products outfall. Clearly, with only a single sampling point, it is impossible to say how widespread the dioxins and furans are. It is to be hoped that the concentrations of these most toxic chemicals are lower in the proposed pipeline corridor than they are close to the assumed source of the pollution. However, in the absence of site-specific surveys, there are no grounds for supposing an absence of dioxins and furans on the Proponents' preferred pipeline route.

Clearly, the sediments that would be encountered when laying a pipeline across the Strait are very seriously polluted, with some extremely hazardous materials being present, though the exact composition and concentrations of the contaminants are spatially varied. It may yet be possible to find a pipeline route across the Strait that avoids any areas of unacceptable contaminant load, though only high-resolution site-specific surveys along a selection of possible routes could reveal exactly where the pipe might safely be laid. No such surveys have yet been undertaken by the SOEP Proponents.

The extent of these sediments is also of note. The Proponents have mentioned a number of studies, one in particular having been being undertaken in the 1960s off Wright Point, in the centre of the proposed pipeline corridor[376]. There, in depths of 26 to 33 m, the seabed was composed of a layer of very soft mud, with a depth of 0 to 5 m. It seems likely that much of this had been deposited in the decade since construction of the Causeway. Beneath it, one of six boreholes found 4.5 m of stiff clay, while another found 2.5 m of gravely sand. Otherwise, beneath the soft mud, all samples found 5 to 11 m of till (a form of glacial deposit, containing a random mixture of clay, silt, gravel and boulders), which in turn overlay bedrock. These results are probably indicative of the sediments that would be encountered by a pipeline crossing, which might have to be trenched through the (presumably contaminated) mud to rest on the till and other firm sediments beneath[377].

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[376] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-70.

[377] Amidst the assortment of information that the Proponents have provided on the sediments of the Strait is some which might give a rather different impression than that offered here. For one, they quote an estimate by the Geological Survey of Canada (GSC) that fine sediments have accumulated in the Strait at the rate of up to 2 mm per year (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-66) and not the hundreds of millimetres per year suggested here. The GSC estimate is doubtless accurate for the times, places and types of sediments that it was intended to address. However, the estimate of a 4 m accumulation of fibre "mat" off the Stora Forest Industries outfall, which the Proponent also cites (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 61), shows that in that area, if no other, average sedimentation has exceeded 120 mm per year since the pulp plant began operations. It is likely that other local pockets have seen considerable accumulation of fine sediment, though yet other areas will have seen very little.

It may also be noted that the Proponents' comment on this fibre "mat" implies that it extends only a kilometre or so from the Stora Forest Industries' outfall. This may well be so but, if true, it shows a marked improvement over the earlier operations of the plant: as early as 1973, after little more than a decade of operations, the area of "blanketing" with wood fibre extended 2.5 km from the outfall, while some fibre was detectable in sediments as far away as Eddy Point [Wilson, R.C.H. (1979) Influence of pollution in the Canso area, A summary. *Fisheries and Marine Service Technical Report* 834(4): 55-59]. Contaminants discharged with the fibre may be expected to have travelled at least as far.

The Proponents have also quoted the results of GSC's earlier mapping of the surficial sediments in the Strait [*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 5-61 to 5-62 & Fig. 5.5-8; MacLean, B., G.B. Fader & L.H. King (1977) Surficial geology of Canso Bank and adjacent areas. *Geological Survey of Canada paper* 76-15]. That mapping, part of a larger effort which covered the entire Scotian Shelf and which has since been extended to the Grand Banks and Georges, classified all of the offshore sediments into a half-dozen groups, of which three were found within the Strait itself: Scotian Shelf Drift, LaHave Clay and Sable Island Sand and Gravel. The availability of this excellent series of surficial sediment maps has attracted the attention of many biologists, who have sought to use them as descriptions of seabed habitats [e.g. Scott, J.S. (1982) Selection of bottom type by groundfishes of the Scotian Shelf. *Canadian Journal of Fisheries and Aquatic Sciences* 39: 943-947]. In reality, however, the geological classification was based on the processes under which the sediments were formed and not on their present characteristics, which can vary markedly within any one map unit. This distinction did not become clear until fishermen's knowledge of seabed types, with its higher spatial resolution and its more

A question must remain over the degree of movement of any sediment that was disturbed during the laying of a pipeline across the Strait. The Proponents have suggested that, in the deeper parts of the Strait, water flows are slow enough that such movements would be minimal[378]. That is certainly a possibility though, when dealing with PCBs, dioxins and furans, it would be well to establish the matter beyond reasonable doubt, rather than relying on facile assumptions. The observed presence of wood fibres from an outfall at Point Tupper as far seaward as Eddy Point[379], along with the deep counter-flow to wind-driven water movements, confined to the immediate vicinity of the Strait's bottom and therefore relatively fast, which was noted in 1973 both suggest that the dispersal of fine sediments, once disturbed by mechanical activity, could be extensive. Certainly, a very much more convincing argument in favour of minimal dispersal is needed before that conclusion should be accepted.

10.1.2 The Biotic Environment

The biotic environment of the Strait is much less well known than its physico-chemical state. The Proponents have not undertaken any studies at all and have only presented a single map of the "habitats" within their self-defined study area. Even this map appears to be based exclusively on the entirely fallacious notion that all seabed shallower than 10 m can be designated "Probable Lobster and Sea Urchin Habitat", while all deeper areas can be left blank[380].

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immediate link to fish distributions, was considered in reference to the published charts [Kenchington, T.J., R.G. Halliday & G.D. Harrison (1994) Fishing grounds exploited in 1990 by groundfish longliners based in Canada's Scotia-Fundy Region. *NAFO Scientific Council Studies* 20: 65-84]. It is now known that the geological classification, while well designed for its intended purpose, is apt to be misleading for others.

In the specific case of the Strait of Canso, the Scotian Shelf Drift is (almost) entirely buried below the immediate seabed but it does at least take its typical form of a poorly-sorted glacial till – as was found in the borehole samples cited above. Offshore, Sable Island Sand and Gravel is indeed the fine-sand to gravel deposit described by the Proponents (their p. 5-67) but in the Strait itself it is, in the words of the original GSC report, "a highly variable mixture of gravel, sand, silt and clay" and, as mapped there, "probably includes some exposures of bedrock or glacial till and locally may be overlain by thin patches of LaHave clay". In other words, the extensive areas of "Sable Island Sand and Gravel" that the Proponents show in the proposed pipeline corridor (their Fig. 5.5-8) are not beds of sand at all but areas with a mixture of everything from bedrock to mud – as the Proponents' report indeed acknowledges (their p. 5-68), though only to a careful reader. Likewise, the LaHave Clay (which, offshore, would be a purely natural, silty deposit in the deep basins of the Scotian Shelf, largely formed at the end of the Ice Age) in the Strait is a sandy deposit, containing some gravel (as might be expected with the fast tidal streams of the era before 1954), though it also includes a thin and discontinuous veneer of fine sediments, probably laid down after construction of the Causeway [MacLean, B., G.B. Fader & L.H. King (1977) Surficial geology of Canso Bank and adjacent areas. *Geological Survey of Canada paper* 76-15]. The distinction between LaHave Clay and Sable Island Sand and Gravel would, therefore, be hard to discern on the floor of the Strait, at least from the perspective of either practical engineering or habitat mapping concerns. In short, the names of the geological map units, with their references to "sand" and "clay", can mislead incautious readers when they are applied within the Strait of Canso. The reality of the geologists' conclusions 20 years ago was fully consistent with the description of the sediments in the likely pipeline corridor that is presented above.

[378] *SOEP Responses to Scoping Process,* p. 33.

[379] Wilson, R.C.H. (1979) Influence of pollution in the Canso area, A summary. *Fisheries and Marine Service Technical Report* 834(4): 55-59.

[380] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment,* p. 5-71 & Fig. 5.5-10. In reality, both lobsters and sea urchins can be found living at depths far greater than any in the

There may indeed be little available information on the biota of the Strait, between the Causeway and Melford Point. Aside from some observations on polychaetes and molluscs taken in the sediment studies of the late 1960s and early 1970s[381], this writer is not aware of any published information. The standard expected of the present Proponents is not, however, simply one of summarizing the available scientific literature but rather one of presenting before the Panel sufficient information on the environment to support a reasoned decision – including undertaking such new field studies as may be necessary. In the case of the biotic environment in the Strait of Canso, that is a standard which the Proponents have entirely failed to achieve.

10.1.3 The Human Environment

The primary human activity within the Strait is commercial shipping. The Proponent has quoted some figures, provided by the Port Manager, outlining the extent of this activity[382]. Evidently, there are nearly 1,000 vessel arrivals each year at the various berths in the Port (which extends from the Causeway to Melford Point), together with the same number of departures. While many of these will be movements of small vessels (including tugs, fishing vessels etc.), they also include a few hundred arrivals of tankers, bulk carriers and barges – some of them very large. Further, the 1,000 arrivals does not include movements of most recreational boats and perhaps not those of inshore commercial fishing boats either. Besides, there are some 2,000 additional vessel (probably including recreational vessel) movements per year through the canal in the Causeway, for an annual total of some 4,000 movements within the Port's limits (not including small vessels, other than those which passed through the canal). Clearly, the Strait of Canso is a very significant area for marine traffic.

Strait of Canso, whereas neither occur (except as rare vagrants) on soft, silty bottoms, even in shallow water.

As this report was being prepared, the Proponents produced a different view of the extent of lobster habitat in the Strait, claiming that it generally extends less than 100 m from each shore, though near Cass Cove it extends 350 m (*SOEP Response to Panel Information Request* 6.13a). The source of this information has not been stated. The measurements are certainly not in accord with *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Fig. 5.5-10, which shows a typical width of "lobster habitat" in the Proponents' pipeline corridor of around 200 m and as much as 700 m in Cass Cove. It is possible, though by no means certain, that the widths cited in *SOEP Response to Panel Information Request* 6.13a are based on accurate sources, such as interviews of the fishermen concerned. Even so, they are likely to refer only to the habitat used by lobsters during the regulated fishing season, which can be much less extensive than the whole area used throughout the year.

The Canada-Nova Scotia Strait of Canso Environment Committee, in an earlier attempt to map the environment of the Strait area, which was little better that the SOEP Proponents' much more recent one, showed an area of "Intensive Lobster Fishery", and thus presumably good lobster habitat during the fishing season, extending from Melford Point to Janvrin Island at all depths but none such in the Strait itself above Middle Melford [Maritime Resource Management Service, Council of Maritime Premiers (1975) *Strait of Canso Natural Environment Inventory: Fish and wildlife resources,* 18 p. plus map].

[381] Wilson, R.C.H. (1979) Influence of pollution in the Canso area, A summary. *Fisheries and Marine Service Technical Report* 834(4): 55-59.

[382] *SOEP Response to Panel Information Request* 5.1j.

There is also some commercial fishing and aquaculture within the Strait. The Proponents have attempted to present some information on these activities[383] but, in the process, they have done themselves a disservice: Their description of fishing activity is based on data on landings within the Strait, rather than catches there. Since the Mulgrave wharf is a favourite point for landing fish from large fishing boats, for road transport to processing plants elsewhere, the Proponents' approach may leave the impression that the fisheries from the Canso Causeway to Eddy Point are worth some $5 million annually. In reality, almost all of that volume of landed fish was caught offshore and had no connection with the marine environment of the Strait, save for the use of its surface as a transport route to the wharf.

The Proponent has also noted that some inshore fishermen live in the communities around the Strait, the holders of a total of 61 licences apparently residing there[384]. Since that count is said to include one scallop licence held in Long Pond (i.e. north of the Causeway), however, one is left to wonder how much of the $299,000 in inshore lobster value, also cited by the Proponents, was in fact caught along the Gulf of St. Lawrence side of the Causeway – an area that has developed a very significant lobster population in the last forty years. At the opposite end of the Proponents' study area, the half-dozen licensed fishermen of Melford and Steep Creek may well do most of their fishing in the broader spaces of Chedabucto Bay, perhaps working out of the wharf at Eddy Cove.

The actual amount of fishing in the part of the Strait from the Causeway to Melford Point would be hard to determine, without interviewing those involved – which the Proponents seem not to have attempted. It must certainly be insignificant when compared to the value of the industrial activity around the Strait, though it may still be seasonally important for a dozen or so people. More seriously, considering the potential for disturbance of PCBs, PAHs, dioxins and other contaminants in sediment trenched for a pipeline crossing, some human food is being taken out of the Strait and the potential for contamination, even if small, should not be ignored – as indeed the Proponents' have acknowledged[385].

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[383] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 5-71 to 5-73. In the 1970s, the Canada-Nova Scotia Strait of Canso Environment Committee mapped a number of fisheries seaward of Melford Point but none at all in the Strait itself, above Middle Melford [Maritime Resource Management Service, Council of Maritime Premiers (1975) *Strait of Canso Natural Environment Inventory: Socio-economic environment*, 17 p. plus map].

[384] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-72. Statistics on numbers of fishing licences are always complex and frequently confusing. The Proponents' tabulation of them in their Table 5.5-24 may not, therefore, leave a realistic impression. It is unlikely that these are the numbers of personal fishing licences (which would provide a count of individual people working on fishing boats and living in the area) but rather one of licences to engage in fisheries subject to limited licensing – which means that each boat should carry one licence per fishery it is used in. However, many boats are licensed for more than one fishery and thus the number of boats is probably very much less than 61 suggested in Table 5.5-24. Even where a licence is held by an inshore fishing captain resident in the Strait area, there is no guarantee that he fishes there. While interviewing fishermen for the Department of Fisheries and Oceans [a study reported in: Kenchington, T.J. & R.G. Halliday (1994) A survey of fishing practices in the Scotia-Fundy groundfish longline fisheries. *Canadian Manuscript Report of Fisheries and Aquatic Sciences* 2225: 642 p.], the present writer has personally encountered a captain living in the Port Hawkesbury area who worked his boat out of Louisbourg – a practice otherwise almost unknown in the Nova Scotian fisheries and probably adopted in this one instance because of a lack of available fish in the Strait area. (Further details of the individual concerned cannot be provided in order to protect confidentiality.)

[385] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 7-23.

There are also two aquaculture sites inland of the Melford Point–Bear Point line, both being near that line and on the mainland side of the Strait[386]. They are both cage-culture sites for salmon and trout and thus involve surface-living animals, fed by the aquaculturists. As such they carry less risk of uptake of contaminants than bottom-cultured filter feeders (e.g. oysters) might. They do, however, lie in the zone of greatest outflow from the industrialized parts of the Strait[387].

Besides these commercial uses of the Strait's waters, there is probably some recreational use, though the Proponents make no mention of it aside from boat transits. In particular, mackerel fishing may be significant in the summer.

Finally, while not of immediate concern in this report, it may be noted that the Strait of Canso also holds rich submerged heritage resources. In earlier times, the Strait was an important shipping route, though a difficult one for sailing craft, with its fast tides and winds channelled by the surrounding hills. Aside from prehistoric sites drowned by rising sea levels (which are probably not detectable with current archaeological capabilities), there are likely to be a number of historic-period shipwrecks within the proposed pipeline corridor. The Proponents have indeed listed no less than 35 named shipwrecks within the boundaries of their Constraint Map #4[388], the only navigable waters of which are the Strait and its adjacent coves, though none of those sites is mapped within the corridor itself. The information on all of these shipwrecks was, however, provided by the Nova Scotia Museum[389], no doubt from their *Nova Scotia Shipwreck Inventory and Database.* Unfortunately, that source has a number of severe limitations as a foundation for a pipeline routing constraints map.

With a few limited exceptions, where field data have been provided to the Museum, their *Database* is not a listing of wreck sites, *per se*, but one of documentary reports of shipwrecks. Until modern times, such reports did not usually include precise indications of location and many of the 35 recorded wrecking events will only be noted in the surviving records as having occurred "in the Strait of Canso" or, at most, by some imprecise geographic designation such as "off Point Tupper". When such data are mapped, they produce the sort of misleading representation seen in the Proponents' constraint map, which shows 13 wrecks at one spot north of Point Tupper, 14 more off the Point and five off Mulgrave[390]. In all probability, these do not represent three locations of extreme nautical hazard but rather three vague geographic descriptors, which have been arbitrarily positioned on the map. Thus, it remains entirely possible that some of the 32 vessels in question were actually lost within the pipeline corridor. Besides, even if originally stranded outside that zone, with wooden ships in an area of extreme water movements, one cannot be certain that substantial pieces of wreckage will not have moved significant distances

[386] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 5-73. *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Fig. 5.5-10 shows only one of these two sites.

[387] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 5-48 & 5-49.

[388] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Appendix D, Table D-1.

[389] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Appendix D, pp. D-5 & D-6.

[390] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Appendix A, Constraint Map #4; Appendix D, pp. D-5 & D-6. The remaining three recorded wrecking events have been mapped with more individual positions, suggesting that the *Nova Scotia Shipwreck Inventory and Database* contains more precise positional information for them.

across the seabed before finally settling into the sediment – as has recently been shown for one wreck elsewhere in Nova Scotia[391].

Furthermore, while a listing of modern shipwreck events can be expected to approximate a list of the corresponding heritage sites surviving on the seabed (at least where large steel vessels are concerned), the same cannot be said of those older wrecks that are of archaeological importance (roughly those dating from before 1850). Not only have many older wooden vessels been destroyed without leaving detectable traces, following their documentary recording, but many others were lost without written record – some of which have survived underwater. The Terence Bay Wreck, for example, is the only internationally-significant shipwreck off Nova Scotia yet to receive detailed archaeological attention[392]. Yet a diligent search of documentary sources has produced no record of her loss and she only appears in the Nova Scotia Museum's *Database* because of the previous archaeological investigations, which arose from her chance discovery.

While not highly likely, it therefore remains entirely possible that an archaeologically-important shipwreck site lies on the Proponents' preferred pipeline route across the Strait – which would require a change in that route[393], perhaps requiring in turn more extensive trenching through contaminated sediments. Certainly, the Proponents, for all of the pages of their submission devoted to heritage resources and constraints on pipeline routes, has done nothing to investigate this possibility. Unless and until site-specific route surveys are undertaken, the potential for a heritage constraint will remain, just as will the potential for unacceptable release of contaminants during trenching.

10.2 The Pipeline Crossing

The Proponents propose to lay their liquids pipeline within this complex environment. However, their EIS provided no information on this crossing whatsoever, beyond indicating a broad pipeline corridor and offering the preliminary suggestion that the Strait could be crossed by either directional drilling beneath or a cut trench across its floor[394]. Subsequently, the Proponents filed their *Addendum 3 : Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, which provided extensive (if still incomplete) environmental information about the Strait but, with respect to the Proponents' plans, did little more than repeat the information in the EIS. Its "Project Description"[395] did not mention the Strait

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[391] Kenchington, T.J. & C. Whitelock (1996) The United States Mail Steamer *Humboldt*, 1851-53: Initial report. *International Journal of Nautical Archaeology* 25.

[392] Carter, J.A. & T.J. Kenchington (1985) The Terence Bay Wreck: Survey and excavation of a mid-18th century fishing schooner. *Historical Archaeology Special Publication* 4: 13-26; Kenchington, T.J., J.A. Carter & E.L. Rice (1989) The indispensability of non-artifactual data in underwater archaeology. *In:* J. Barto Arnold (ed.) *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference 1989*: 111-120; Kenchington, T.J. & E.L.R. Kenchington (1993) An eighteenth-century commercial length-frequency sample of Atlantic cod, *Gadus morhua*, based on archaeological data. *Fisheries Research* 18: 335-347; Kenchington, T.J. 1994. An 18th century precursor of the fishing schooner's 'great beam' or 'break beam'? *International Journal of Nautical Archaeology* 23: 35-38; Kenchington, T.J. & J.A. Carter *In press* Terence Bay Wreck. *In:* J.P. Delgado (ed.) *Maritime and Underwater Archaeology: An encyclopedia.* Garland Publishing, New York.

[393] Proper excavation of any such site would be both too costly and far too time-consuming to be a viable alternative.

[394] *SOEP Volume 3 – EIS* p. 3-14, Fig. 3.1-4.

[395] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Section 3.

crossing at all, though elsewhere it did re-state the options of either drilling or trenching[396]. The 3 km pipeline corridor presented in the EIS was also discarded in favour of one 4 km wide and some 2.5 km seaward of that originally proposed[397]. The Proponents also offered three alternative pipeline routes for the Strait crossing, spread about 2 km apart[398], though their submissions leave the impression that those specific proposals have been discarded in favour of the wider corridor.

When the inadequacy of this limited information on the crossing was noted by the Ecology Action Centre[399], the Proponents responded by suggesting that the pipeline might be trenched, dredged or ploughed into the seabed, or passed beneath it using directional drilling[400] – none of which provided any greater understanding of their intentions than had been available before. They further stated that the sediments of the pipeline route would be sampled before any construction activity and that mitigative measures would be taken to ensure that any impacts were within the limits accepted by the regulatory agencies[401], which only restated an earlier commitment[402].

In reply to the Panel's *Information Request* 5.1b, however, the Proponents did amplify their earlier information somewhat, stating that the conventional approach to the Strait crossing would be to lay the pipeline into a trench dug by a clamshell dredge, while jetting or ploughing the pipe into the seabed would be other alternatives. The option of directional drilling (which would clearly have the least environmental impact on the Strait[403]) was then noted to be near the upper limit of current technology for that technique and subject to geotechnical limitations that had yet to be examined with reference to the Strait of Canso area[404]. This strongly suggested that the most environmentally-desirable option, at least from a marine perspective, had been set aside by the Proponents, though it otherwise hardly extended understanding of their proposals at all.

Amongst all of this uncertainty and incomplete information, what is clear is that the Proponents intend a pipeline crossing of the Strait of Canso that would be a not-insignificant construction project in its own right, though only be a small component of SOEP. A project of this magnitude deserves serious attention in an EIS, yet the Strait crossing has been placed before the Panel for review without even an outline design of the work being offered – making any serious environmental analysis impossible.

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[396] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 6-11 and 7-22.
[397] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 4-9 to 4-11 & Appendix A, Constraint Map #4. Nowhere have the Proponents made clear that their plans have changed in this way, though it is evident from a comparison of their various maps.
[398] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Fig. 4.3-1.
[399] *Deficiencies in the SOEP Environmental Impact Assessment: Marine ecosystems & fisheries issues*, p. 11.
[400] *SOEP Responses to Scoping Process*, pp. 32-33.
[401] *SOEP Responses to Scoping Process*, pp. 32-33.
[402] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 8-15.
[403] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 6-11.
[404] *SOEP Response to Panel Information Request* 5.1b (p. 27).

10.3 Environmental Effects of the Strait Crossing

10.3.1 Directionally-Drilled Crossing

The Proponents have correctly stated that passing their liquids pipeline through a directionally-drilled tunnel would not involve any marine impacts, except for the possibility of some release of drill muds through bedrock fissures or gravel sediments in the seabed[405]. That potential effect should not be dismissed, however, considering the nature of the seabed under the Strait. With its 45 m depth being underlain by a further 30 m of till[406], at least in some parts, driving the drilling deep enough to isolate it from the Strait's waters might not be easy. Such concerns have, however, become rather unimportant as the Proponents seem to have moved away from the drilling option, as noted above.

10.3.2 Seabed Crossing

The other alternatives offered by the Proponents are all ways of laying a pipeline across the floor of the Strait. These would involve some inconvenience to other marine activity in the Strait during the construction period[407], though it is likely that such conflicts could be resolved without difficulty. A greater concern, which the Proponents have not addressed[408], is the risk to the completed pipeline, and hence to the surrounding environment, from the pipe being fouled by a ship's anchor. There would, no doubt, be a safety zone around the pipe in which anchoring would be prohibited and it is unlikely that any captain would seek to anchor in the deep and narrow waters of the Strait. However, power failures do occur at awkward moments in even the best run ships and it is normal practice in many ports for ships to drop an anchor in an emergency. In the Strait of Canso, their ability to do so is already limited by a number of pipelines and cables[409]. It may be that one more pipeline would not pose any particular difficulty to the captains and pilots of the large ships entering and leaving the Port. Conversely, declaring another safety zone might block the one remaining emergency anchorage. Certainly, the Proponent has not filed any comment from those involved in shipping activities in the Strait confirming that the pipeline is acceptable to them. This should be resolved before any proposal to lay a pipe across the Strait is approved.

The Proponents have listed a number of other possible pathways by which a trenched crossing might affect the marine environment, noting in all cases but one that "further analysis is required"[410], and they have briefly summarized the likely effects. The latter

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[405] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 6-11, 7-22. Drill muds are mentioned by the Proponent only in the context of a release of bentonite. Assuming that OBM is needed for directional drilling of a pipeline tunnel, as it would be for a gas well drilled at a similar angle, then the oil and other constituents in the mud could be released along with the bentonite.

[406] MacLean, B., G.B. Fader & L.H. King (1977) Surficial geology of Canso Bank and adjacent areas. *Geological Survey of Canada paper* 76-15.

[407] As the Proponents have noted: *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 6-12.

[408] Except for a generic comment on the effects of a rupture in the pipeline, which they state needs "further analysis": *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 6-13.

[409] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, Fig. 5.5-10.

[410] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 6-11 to 6-13. The one exception to the stated requirement for further analysis is underwater blasting. That pathway was dismissed from concern on the grounds that "Blasting is not likely required in construction of the marine portion of the pipeline and thus no impacts are anticipated". Those are not sufficient grounds. Unless

include very localized (little wider than the pipe itself) and temporary alterations to seabed habitats, the temporary obstructions to other water users noted above and some potential for accidental release of contaminants during the pipelaying. The Proponents suggest that, "if possible", they would schedule the pipelaying to avoid the local lobster fishing season, if anyone fishes lobster near the chosen pipeline route[411]. They consider the possible consequences of blasting for fish, but only in terms of immediate mortality at short range and not the more extensive behavioural disturbance produced by sub-lethal blast pressures[412]. All of these impacts are deemed reducible to negligible impacts through appropriate mitigation measures[413]. So they may be, though the evidence for that has not been presented to the Panel and the Proponents' own admissions that further analyses are required suggest that the matter is still an open question.

The most serious potential effect of a seabed pipeline crossing of the Strait is, however, none of the above but rather the disturbance of the contaminated sediments in the Strait. The Proponents have fully acknowledged this, stating "It is likely that significant impacts could occur" and "Mitigation measures [. . .] are required"[414]. For those measures, they have proposed a site-specific sediment survey, with steps being taken to adjust the pipeline route to avoid contaminated areas, adoption of less-disturbing techniques (e.g. ploughing, rather than dredging), the use of technology such as silt screens, or even contaminants containment and disposal at an approved facility. With a proper implementation of such measures, the Proponents have suggested that there would be no significant residual adverse impacts[415]. That suggestion, however, begs two important questions: whether a combination of the available methods would be effective and, if so, whether there would indeed be "proper implementation".

A high-resolution site-specific survey of sediments and other constraints to pipeline routing is certainly needed, as has been stated above. Whether or not it would be possible to avoid the contaminated areas thus revealed must remain a matter for conjecture until the survey results are available – as they should be before this pipeline route can be approved. If such avoidance cannot be achieved, ploughing might reduce impacts relative to trenching but silt screens would be of little value; even the Proponents have admitted that they could only be used in shallow water and disturbed sediments at greater depth (where the highest concentrations of contaminants, aside from those close to point sources, may be expected) would simply be assumed not to disperse[416]. As argued above, that assumption has, as yet, no secure foundation and cannot be trusted. Further, without the screens, the notion of contaminants containment and safe disposal is meaningless – raising dredged sediment all of the way to a scow would only serve to disperse the contaminated fine fraction into surface waters, where the potential for human exposure is greater. Certainly, no specific

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underwater blasting has been ruled out entirely, it must be deemed to remain as a potential pathway. Indeed, later in the same document, the Proponents also stated that "Blasting may be conducted" and that it "could result in significant adverse impacts" such that "mitigation will be required" (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 7-24), though they also suggest that the available mitigation measures would be adequate to ensure no residual impacts (*SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 8-15).

[411] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 7-24.

[412] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 7-24.

[413] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 8-11 to 8-16.

[414] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, p. 7-23.

[415] *SOEP Addendum 3 – Natural Gas Liquids Pipeline and Liquids Facilities Assessment*, pp. 8-15 to 8-16.

[416] *SOEP Responses to Scoping Process*, p. 33.

plans for mitigation measures, the efficacy of which could be reviewed, have been advanced by the Proponents.

The Proponents will no doubt argue, as they already have[417], that whatever mitigation measures they finally selected would be subject to approval by appropriate regulatory agencies. Unfortunately, the relevant agencies do not have much more credibility in this area than the Proponents themselves, even under favourable circumstances. If the Panel once gives general approval to SOEP, the likelihood that any environmental regulatory agency would delay the Proponents' preparations over an issue such as laying a secondary pipeline across the Strait of Canso is insignificantly small.

SOEP is subject to review before the Panel and, in this writer's opinion, all of its effects must be examined in that forum before any overall approval to proceed is issued.

10.4 Summary

Laying a natural gas liquids pipeline across the Strait of Canso raises a number of environmental concerns, of which the most serious is the potential for dispersal of the seriously-contaminated sediments off Point Tupper. How serious that risk is remains unknown, since the Proponents have declined to submit even a firm description of their specific proposal for the crossing of the Strait, let alone a proper EIA for this part of their overall project. It is not likely that laying the pipeline would cause a major disaster. However, where PCBs, dioxins and furans are concerned, caution is always advisable. Thus far, the SOEP proposal has not demonstrated it in regard to this part of its pipelines.

[417] *SOEP Responses to Scoping Process*, p. 33.

11. Environmental Effects Monitoring

Despite the Proponents' insistence that their submissions allow confident predictions of the impacts of SOEP[418], all discussions of the environmental effects of offshore petroleum exploration and development are necessarily imprecise and uncertain. Scientific knowledge of marine ecosystems and the effects on those systems of offshore petroleum activity are by no means sufficient to support confident predictions. Indeed, what confidence the scientific community had a decade ago has been wiped out by disturbing discoveries in the North Sea, as discussed in Section 5.2 above.

This lack of fundamental knowledge should not, alone, be taken as justification for rejecting the Proponents' proposals. As argued elsewhere, there is much specific information that they could and should have provided on SOEP, the environment of the eastern Scotian Shelf and the effects of the project on that environment. Until that information is provided and is used in a valid EIA, in this writer's judgement, the SOEP proposal should be set aside. However, even had all available knowledge, and that obtainable by reasonable use of existing methodology, been drawn into the Proponents' EIS, there would still be great gaps in our ability to predict SOEP's impacts on the environment – gaps that only time and research can fill.

Even if all offshore petroleum activity were delayed for some decades, while marine ecologists developed a deeper appreciation of the ocean, we would still not have a foundation for predicting the impacts of exploration and development since that requires not only knowledge of the environment but also of the effects of development on the environment. While nobody would suggest developing an offshore oil or gas field simply to generate data for an "applied ecology" study of impacts on marine ecosystems, when any offshore project is approved (on the basis of a balance of probabilities of its risks and benefits, for lack of a more certain basis), it is critically important that that development be "used" as just such an "experiment", so that future regulatory decisions can be built on more trustworthy foundations – and ultimately on the elusive confident predictions that the present Proponents evidently desire.

These sorts of "experiments" around offshore installations, the data-collection component of which is termed "Environmental Effects Monitoring" ("EEM"), began in the early 1970s in the Gulf of Mexico and at about the same time around selected platforms in the North Sea. It has been legally required in the United Kingdom sector since 1984, at about which time it was also implemented in the Californian offshore fields and around the exploratory wells drilled on Georges Bank[419]. It is this work that has provided what limited knowledge

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[418] Letter from R.H. Harper to the Secretariat of the Joint Review Panel, 6 December 1996.

[419] Davies, J.M., R. Hardy & A.D. McIntyre (1981) Environmental effects of North Sea oil operations. *Marine Pollution Bulletin* 12: 412-416; Carney, R.S. (1987) A review of study designs for the detection of long-term environmental effects of offshore petroleum activities. *In:* D.F. Boesch & N.N. Rabalais (eds.) *Long-term Environmental Effects of Offshore Oil and Gas Development.* Elsevier, London: 651-696; Brewer, G.D., F. Piltz & J. Hyland (1987) Monitoring changes in benthic communities adjacent to OCS oil production platforms off California. *Oceans '87* I.E.E.E., New York: 1593-1597; Johnston, C.S., A.H. Gillan & J. Side (1987) The development and current status of environmental monitoring programs in the North Sea. *Oceans '87* I.E.E.E., New York: 1531; Neff, J.M., M.H. Bothner, N.J. Maciolek & J.F. Grassle (1989) Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. *Marine Environmental Research* 27: 77-114; Brewer, G.D., J. Hyland & D.D. Hardin (1991) Effects of oil drilling on deepwater reefs offshore California. *American Fisheries Society Symposium* 11: 26-38.

we have of the environmental effects of the offshore petroleum industry and it is this work that, in the Norwegian sector of the North Sea, has recently led specialists to reject earlier conclusions and revise their views about those effects[420]. It is the concentration of this work in warm-water environments and the deep northern North Sea that makes predictions of the effects of SOEP, situated in a shallow, high-energy but cold environment, so uncertain. Next to no studies have yet been made of the environmental effects of offshore gas production in such an area.

If the regulatory reviews of future offshore projects, including future gas projects on the Scotian Shelf, are to have the benefit of a more solid foundation than the present SOEP review can have, then it is imperative that SOEP (should it proceed) be accompanied by an effective EEM program.

The Proponents have acknowledged this requirement[421]. They have also linked it to monitoring designed to support "the development of mitigative and compensatory measures" through "adaptive environmental management"[422]. This is an attractive idea, in that it promises to use knowledge gained from the monitoring to reduce further any adverse impacts that the project may be found to have on the environment. Unfortunately, effective EEM programs must examine subtle effects on a naturally-variable environment. Thus, they rely on statistical analyses which can only be performed after prolonged data collection and, often, laboratory processing of samples. Such analyses produce probabilistic results and not, usually, the indisputable conclusions that can justify expensive modifications to on-going projects. Further, unless the monitoring is either to be grossly expensive or else restricted to studying questions that can only produce trite answers, it will usually be impossible for EEM to yield conclusive <u>causal</u> results. That is, a change in the environment may be demonstrated beyond a reasonable doubt but the link between that change and some development project will usually only be inferred.

Clearly, as new knowledge is gathered, it should be used to improve the environmental safety of on-going projects. The SOEP Proponents should be applauded for their intention to do so. However, if the SOEP EEM program was confined to being a data input process for adaptive environmental management, it would fall far short of efficiently extracting new knowledge about the impacts of offshore gas production on the Scotian Shelf from such impacts as SOEP caused. Further, tying EEM to environmental management of SOEP would introduce an incentive for the Proponents to reduce the chance that the EEM would detect any impacts. Whether or not they responded to this incentive, its very existence would serve to discredit the applied-ecological-research aspect of the EEM. Thus, while monitoring should remain a fundamental part of the SOEP Environmental Protection Plan ("EPP"), there should be a research-oriented EEM program outside of the operational aspects of that EPP.

Indeed, while Compliance Monitoring involves routine recording, to regulated standards, of emissions that are directly relevant to the operations of the project, and hence can usually be left to a developer's personnel, EEM is a subtle process, requiring considerable skill in

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[420] Warwick, R.M. & K.R. Clarke (1991) A comparison of some methods for analysing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom* 71: 225-244; Olsgard, F. & J.S. Gray (1995) A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. *Marine Ecology Progress Series* 122: 277-306.
[421] *SOEP Volume 3 – EIS* pp. 8-10 to 8-12.
[422] *SOEP Volume 3 – EIS* pp. 8-11.

the design of ecological experiments and close attention to many natural-science issues that are far from the usual concerns of the offshore oil industry. Superficially-minor alterations to monitoring designs can all too easily render an EEM program incapable of detecting anything – most of the amendments that seem to promise efficiency and reduced costs will in fact invalidate the entire process, wasting whatever resources are expended on it, as has happened too often in the past. To further complicate the situation, monitoring procedures that have been (and too often still are) accepted as standard within the environmental-management community are statistically invalid and must be discarded[423], while the questions commonly addressed, and likely to be adopted by any corporate monitoring effort, have been rendered all but irrelevant by the North Sea work, which has shown that distant environmental effects of drilling can and do occur.

Any major EEM program starting in the 1990s should, therefore, be under the effective direction of specialist scientists, at "arms-length" from the project that they are monitoring. This is doubly necessary in the case of SOEP since the mechanisms suggested by the Proponents for directing their monitoring[424] are seriously inadequate as a basis for EEM, casting doubt on the Proponents' sincerity in their monitoring efforts. The inadequacies include, but are not limited to, the following:

- The Proponents have specifically stated that they "are responsible for seeing that an acceptable EEM program is carried out",
- The Environmental Effects Monitoring Advisory Group, which would be the sole quasi-independent review body for this program, would itself be "proposed, funded and implemented" by SOEP, with the chair and one other member representing SOEP, one of the two scientist-members being a consultant (presumably paid by SOEP), and two of the remaining seven members representing energy (rather than environmental) regulatory agencies,
- Only the three (of eleven) seats on this Advisory Group for the fishing industry and environmental NGOs (plus, perhaps, the one seat for an academic) offer any credible independence from the Proponents' commercial agenda and even the individuals who filled those seats would be "invited" to do so by SOEP and would be selected "for their expertise in specialized subjects, and not as representatives of any organization" [a stipulation that can hardly apply to the appointees from government agencies or from SOEP itself],
- Potentially, none and at most two[425] of the members of this Advisory Group would have any professional understanding of the stringent technical demands of effective offshore EEM,
- Further, this Advisory Group would report to the SOEP Operations Manager and not to the regulatory agencies or the public,
- Support for the Advisory Group would be "voluntary" on the part of SOEP and would only continue for five years (to 2001), not for the entire duration of

[423] See, for example: Hurlbert, S.H. (1984) Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54(2): 187-211; Underwood, A.J. (1992) Beyond BACI: The detection of environmental impacts on populations in the real, but variable, world. *Journal of Experimental Marine Biology and Ecology.* 161: 145-178.

[424] *SOEP GH-6-96 Additional Written Evidence* pp. 20-21.

[425] Both the Department of Fisheries and Oceans' Science Branch and the Nova Scotian academic community include individuals with appropriate training, though there is no assurance that those individuals would be appointed to the Advisory Group.

SOEP, and beyond into a post-project recovery period, as would be required for any study of the long-term effects of offshore gas production[426],

· The Advisory Group's mandate would be exclusively to "advise", "assist" and "make recommendations to" SOEP and not to require or direct that the EEM program be executed effectively, even though the Proponents have stated that "the final details of the program will be determined [. . .] (by an EEM Advisory Committee)"[427],

· The program would be confined to the monitoring of specific "Monitoring Parameters" (e.g. petroleum hydrocarbon concentrations) relative to set "Maximum Acceptable Effects Levels", in selected "Target Species" (e.g. turbot[428], scallops), an activity which would barely constitute EEM at all and is entirely insufficient for studying the environmental effects of SOEP.

No monitoring program so severely constrained can possibly be adequate or acceptable[429].

There is also a question of timing. The Proponents have stated that "EEM studies should be identified early in the EIA process", that "the EEM program should be developed in consultation with the regulatory authorities and the scientific community and stakeholders", that the Advisory Committee will select the Target Species and Monitoring Parameters, that testable hypotheses will then be formulated, that "detailed standard operating protocols will be established", and that a field baseline survey will <u>then</u> be undertaken[430]. Yet, as of the mid-January filing of the Proponents' *Additional Written Evidence*, all that had been done was to set out the characteristics and mandates of the Advisory Committee and to define, on their behalf, eight points of focus for the "EEM" program[431]. To early March 1997, no

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[426] As proposed (*SOEP Volume 3 – EIS* Fig. 3.2-1), four of nine wells at *Venture* and all of those at *South Venture, Alma* and *Glenelg* would not be drilled until 2004 and later. An EEM program that ended in 2001 would thus be unable to make <u>any</u> study of environmental effects of operations at the deeper *Alma* and *Glenelg* sites and little enough at the shallow *Venture* and *South Venture* ones.
[427] *SOEP Volume 3 – EIS* pp. 8-11.
[428] Although cited by the Proponents as a possible Target Species for EEM (*SOEP Volume 3 – EIS* p. 8-12), turbot (*Reinhardtius hippoglossoides*) does not occur in sufficient quantities near Sable Island to provide regular samples for monitoring purposes. The reported commercial catch from the entire Scotian Shelf in 1995 was only 50 tons and most of that was taken well to the eastward of the SOEP area (*DFO Atlantic Fisheries Stock Status Reports* 96/62 & 96/74).
[429] While not necessarily related to the Proponents' proposed EEM program, they have recently provided some indications of the qualifications they would expect of the "environmental inspectors" that they intend to hire to work on the project (*SOEP Response to Panel Information Request* 6.15). If these "inspectors" are not themselves engaged in EEM work, it seems reasonable to expect that the Proponents would aim to use similarly-qualified individuals in that work. The "environmental inspectors" would, as a minimum, have a either an undergraduate degree (in a relevant science or in engineering) or a non-degree certificate in environmental technology, plus two years experience in environmental management or construction. Thus, a professional engineer with two years' work on construction projects would be deemed qualified to monitor the environmental aspects of the project. Those engaged in offshore work would be in a separate team from those onshore but there is no commitment that the individuals in either case would have specialized education relating to the area they were hired to inspect. Indeed, the Proponents appear to think that an "appropriate" level of specialization for a pipeline route survey is that of a general "biologist". These standards are quite simply inadequate for work requiring individual judgement, without immediate recourse to professional supervision.
[430] *SOEP Volume 3 – EIS* pp. 8-10 to 8-12. Emphasis added
[431] *SOEP Additional Written Evidence* pp. 20-21; *SOEP – Responses to Scoping Process* Issue #22.

membership of the Committee had been announced and, if there has been any attempt to consult with stakeholders, it has not included the primary environmental NGOs intervening in the review process. The time available to develop adequate monitoring protocols and applying them in a baseline survey before the Proponents' proposed starting date is, therefore, now critically short and possibly already insufficient.

This entire Environmental Effects Monitoring proposal should be set aside and the Review Panel should recommend, as a condition of any approval of the SOEP proposal, that an EEM system with the following characteristics be implemented:

- Directed at arms-length from the SOEP Proponents and from any government which has demonstrated its support of the SOEP proposal in advance of receiving the Panel's report,
- Funded by government from royalty payments, under long-term commitments to the work,
- Science-driven but reporting to all stakeholders, including the Proponents, as befits what should be an applied-research program, and
- Tasked to address a suite of questions concerning the environmental effects of SOEP that can be efficiently answered within the confines of the program[432].

It is not possible for the people of Canada to realize the value of their offshore geological resources without to some degree degrading the marine environment. Nor is it possible to fully rehabilitate that degradation, using part of the wealth derived from the SOEP wells. It is, however, possible to use some of it to increase our understanding of marine ecosystems and the effects on them of offshore hydrocarbon development, such that future projects will realize economic returns with less risk of environmental harm. A properly constituted EEM

Of the eight points set out in the latter reference, two involve liaison, and not monitoring at all. Two others have been given the tasks of "Confirming the absence of SOEP impact on", respectively, sable Island and the marine mammals of the Gully – tasks that are logical impossibilities as defined. There are then two water-quality monitoring exercises, one general attempt to monitor effects on the Country Island roseate tern colony and an expressed intent to monitor the effects of drilling discharges. This last has been the primary focus of EEM work in the North Sea.

[432] It is neither necessary nor possible for <u>all</u> potential environmental effects of SOEP to be monitored. Nor is it adequate to confine the monitoring to the same easily-measured parameters that have been studied around other offshore production platforms. The selection of studies to be undertaken should be made with due consideration to what is already known, to what gaps in knowledge are most critical to future environmental planning and to which of them can be filled using available monitoring techniques and technology.

Environment Canada has also proposed a system for administering the EEM program different from that advanced by the Proponents. They have called for a seat on SOEP's EEM Advisory Group for Environment Canada but they have also, and separately, called for the entire environmental management program (including the EEM) to be administered by an "independent third party", registered under ISO 14000 or ISO 9000 [Letter from A.R. McIver, Environment Canada, to the Secretariat of the Joint Review Panel, 4 February 1997, point #2; Department of the Environment, Atlantic Region (1997) *Technical comments with regard to the offshore component of the Environmental Impact Assessment – Sable Offshore Energy Project* p. 6]. Placing more than just the EEM program under independent control seems unnecessary. Requiring ISO registration on the part of the program manager would probably, in practice, render the EEM program useless: there are, perhaps, a half-dozen scientists in Canada competent to design an effective EEM program for SOEP. It is unlikely that any of them work for an entity, such as a consulting company, large enough to bear the costs of such registration.

program would provide that increase in understanding and, in doing so, would provide some small repayment to the environment for the damage done in extracting wealth from far below the seabed.

12. Conclusions

The primary conclusion from this review, stated several times already and supported with many arguments and points of detail, is that the SOEP Proponents have failed to place before the Panel an adequate Environmental Impact Statement, containing a valid Environmental Impact Assessment. In consequence, it is not possible, in my professional judgement, for the Panel or anyone else to determine, with reasonable certainty, the degree of harm to the marine environment that SOEP would cause. I therefore suggest that the SOEP EIS and its conclusions should be rejected, even though that would require rejection of the entire proposal.

Rejection of a socially and economically beneficial, and environmentally benign, project on the grounds of inadequate environmental analysis alone would be a tragedy. There are, however, grounds to suppose that, behind the uncertainties surrounding SOEP's environmental implications, lie real and undesirable impacts which, if they were adequately understood, might out-weigh the various benefits of the project, in the judgement of the Panel and the public. Until those impacts are properly investigated and the results placed before the Panel in the form of an adequate EIS, I submit that the project should not be approved.