The OEER / Stantec Reports : A Critical Review

Trevor J. Kenchington Ph.D.
Gadus Associates
Musquodoboit Harbour, N.S.

prepared for

NORIGS 3

December 2010

SUMMARY

- In 2009, the Nova Scotia Department of Energy funded preparation of two reports, entitled *Preliminary Review of Environmental and Socio-Economic Issues on Georges Bank* and *A Preliminary Review of Existing Technologies and their Mitigative Potential in Offshore Petroleum Developments*, through the Offshore Energy Environmental Research Association. The reports were to update the knowledge relating to the moratorium on petroleum activity on Georges Bank that had been available to the Panel Review of 1999. Both reports were prepared by Stantec Inc. and became available in October 2010. Although a decision to extend the moratorium has been announced, these OEER / Stantec reports may yet become important. The NORIGS 3 interest group thus sought this commentary on Stantec's work.
- Both reports were seriously compromised by a lack of specialized expertise amongst their authors and by *a priori* assumptions which shaped their conclusions.
- Their treatment of the environmental impacts of seismic surveys was deficient. What little is known of sublethal impacts on fish was largely disregarded, with the published literature being selectively cited. Behavioural impacts on fish were misrepresented, even the arguments made before the 1999 Review Panel being ignored, and such impacts on whales were downplayed. The suggested mitigation measures would be helpful but still fall far short of addressing all major concerns.
- Stantec devoted much space in both reports to advances in oil-based drill muds and in their removal from drill cuttings before the latter are discharged into the ocean. The concern with drilling on Georges Bank, however, relates to bulk discharges of water-based muds, since scallops and other filter-feeding species are highly sensitive to the barite and bentonite in the

GADUS ASSOCIATES

mud. Neither report offered much on that issue.

- Stantec's suggestion that directional drilling might mitigate some effects of drilling-waste discharges would have been sensible if the issue concerned a small protected area. The approach is not, however, applicable to the broad expanse of Georges Bank.
- Stantec repeated a false claim that the incidence and severity of spills and blowouts from offshore installations have reduced over time. The available data actually show no progress since the 1960s – in contrast to the tanker industry, which has shown dramatic reductions in accidents. Stantec also downplayed the severity of the impacts of spills on marine biota, raised a spurious comparison with natural oil seeps, failed to explain the lack of effective clean-up techniques for use offshore and favoured the application of dispersants – a singularly unfortunate suggestion for Georges Bank.
- The old myth of a comfortable "coexistence" of the fishing and petroleum industries in other areas was trotted out yet again, despite it having been repeatedly debunked.
- Stantec placed great store on conclusions from Environmental Effects Monitoring ("EEM") around existing Atlantic Canadian offshore petroleum sites, claiming *inter alia* that the monitoring has demonstrated a lack of either population-level effects or effects on species at risk. That was entirely spurious. EEM programs can only detect effects that they were deigned to look for and they are rarely, if ever, designed to monitor at the population level. More generally, few EEM programs have adequate power to detect effects of ecological significance, should they occur. The absence of any detected effect thus demonstrates only the inadequacy of the monitoring, not an absence of important effects.
- One of the few areas which has seen genuine progress over the past dozen years is the legal, regulatory, administrative and voluntary controls on the offshore petroleum industry. The advances have been minor (and considerably less than claimed by Stantec) but real. What was not discussed in either report, however, was the inherent weakness in having a single agency, the CNSOPB, responsible for revenue collection from, regulation of, and the protection of the marine environment from the offshore industry. The unavoidable conflicts of interest in that management structure have led to a breaking up of such agencies, with the United States joining that trend during 2010 and the Government of Newfoundland and Labrador currently considering doing so.
- Perhaps the worst deficiency of the two reports was a persistent misrepresentation in their summaries of the contents of their main texts. Those texts failed to dismiss the concerns which led to extension of the moratorium in 1999, yet no hint of that failure will be found in the summaries. Few decision-makers can afford the time to read the whole of such reports and it is important that they are properly summarized. Stantec failed to do so.
- Stantec ended by declaring that the issues identified by the 1999 Panel Review could now be mitigated. However, neither evidence nor argument to support that claim was advanced in either report. None could be as the claim was patently false.
- **Stantec's reports were not entirely lacking in merit but were, in parts, seriously deficient. I cannot recommend that they be given much credence. Neither report offered anything amounting to a justification for reversing the 1999 decision to retain the moratorium on petroleum activities on and around Georges Bank**

Introduction

In 1988, an area of "moratorium lands" encompassing the Canadian portion of Georges Bank and adjacent waters was closed to all petroleum exploration or development activities until 2000. The legislation establishing the moratorium (which took the form of matching amendments to the Accord Acts of Canada and of Nova Scotia) required a public-review process before a ministerial decision to either extend or terminate the closure. In the event, the appointed Review Panel produced the *Georges Bank Review Panel Report* (hereafter the *Panel Report*) in 1999 and recommended an extension of the moratorium. Through a joint Gazetted decision of the respective Federal and Nova Scotian Ministers, the extension was made until the end of 2012.

The two governments were due to decide during the spring of 2010 whether to further extend the moratorium, to terminate it or to refer the question to another public review. Before any such decision could be reached, the disastrous blowout of a well in the Gulf of Mexico, drilled by the rig *Deepwater Horizon*, occurred. With graphic images of the resulting devastation appearing daily in the media, on 13 May 2010 the Premier of Nova Scotia announced an extension of the moratorium, though only for three years[1]. That decision was given further support in December 2010 by an Act of the Nova Scotia Assembly, the *Offshore Licensing Policy Act*, directing the Provincial Minister of Energy to use his powers under the Accord Acts to prevent petroleum activities on Georges Bank until a resolution of the House decides otherwise, such resolution following a recommendation of a public review, which the Minister is not to call before the end of 2022[2].

Before these policy decisions were made, the Nova Scotia Department of Energy had provided funding to the Offshore Energy Environmental Research Association ("OEER"), a consortium of universities and the Department, to fund the preparation of two technical reports which would update the knowledge that had been available to the Review Panel in 1999 – one dealing with new or improved technologies available to the petroleum industry, the other focused on knowledge of the environment (socio-economic as well as natural) on Georges Bank and the potential effects on it of oil and gas activities. Following competitive bidding, contracts for the preparation of each of those reports was given to the consulting company Stantec Inc. in the fall of 2009. The reports were completed in June 2010, under the titles *Preliminary Review of Environmental and Socio-Economic Issues on Georges Bank* (hereafter the *Environmental Report*) and *A Preliminary Review of Existing Technologies and their Mitigative Potential in Offshore Petroleum Developments* (hereafter the *Technologies Report*). Following the usual period of study within the Department, the two reports became available to the public early in October 2010.

---

[1] http://www.gov.ns.ca/news/details.asp?id=20100513005

[2] The *Offshore Licensing Policy Act* or to give it its full title *An Act Respecting a Moratorium on Petroleum Activity on Georges Bank*, Chapter 40, Acts of 2010, received Royal Assent on 10 December 2010.

Although a Provincial decision to extend the moratorium has been announced, the status of the moratorium remains unclear. By its own explicit terms, where there is conflict between the *Offshore Licensing Policy Act* and the Accord Acts, the latter prevail, while they do not appear to allow for unilateral Ministerial extension of a moratorium but only for joint Federal / Provincial directives.

Debate about petroleum exploration and development on Georges Bank thus continues and the two OEER / Stantec reports might yet to play significant roles in shaping further decisions in the coming months. The NORIGS 3 interest group therefore asked its consultant scientist to review Stantec's work and to place on record any comments or criticisms. Those comments comprise the current document.

Overall, I find the two OEER / Stantec reports to be of variable quality but, in parts, seriously deficient. I cannot recommend that they be given much credence.

General Comments Common to Both Reports

Authorship

Each report bears the logo of OEER, as well as Stantec's, and hence the consortium must bear some responsibility for their content. However, there is no indication that OEER's involvement included any academic review or other quality-control process to vet the reports, which appear to be Stantec's work alone – save for portions prepared by a subcontractor, Gardner Pinfold Consulting Economists Ltd. The actual authors or "Study Team" (*Environmental Report* p. i; *Technologies Report* p. i) comprised a "Key" group, two senior reviewers and three named scientific contributors. None of the "Key Study Team" members have extensive research experience in any of the issues raised in either report: None was an author of any of the literature that they cited, though one of Stantec's senior reviewers, Mr. Hickey, was a junior co-author of a 2002 conference presentation that was cited. In contrast, each of the three scientific contributors is a noted expert, though their fields of expertise do not include the environmental effects of offshore petroleum activities.

From the content of the two reports, it does not even appear that any of the "Key" members had first-hand knowledge of the Review Panel's work of 1998–99. Their remarks on that central focus of Stantec's task seem limited to a reading of the *Panel Report*, without reference to either experience at the public hearings or the evidence then presented.

This general lack of relevant expertise need not negate the reports' contents but it does define their nature: Both the *Environmental Report* and the *Technologies Report* were the result of a compilation of some available information gathered over a few months during 2009–10, not a summary of long-nurtured professional understanding. The information

presented by the authors should not be dismissed on that ground alone but it can only be accepted when supported with documentation and citations, not as a matter of expert opinion. Stantec's explicit attempt to found its corporate conclusions on "the professional opinion of Study Team authors" (*Environmental Report* p. 6.1; *Technologies Report* p. 3.1) must be rejected since those authors simply lacked the expertise required to form such opinions.

Orientation

Stantec seriously compromised both reports, but especially the *Environmental Report*, by the approaches that were taken to the tasks at hand. Firstly, both reports perpetuated the too-often heard myth that the 1999 Review Panel recommended an extension to the moratorium because of knowledge gaps (*Environmental Report* p. 1.2; *Technologies Report* p. 1.2). The gaps are real, of course: All decisions in environmental management must be made in the face of massive uncertainties. However, the Panel made no statement of any extension to the moratorium being required because of a lack of information. While the inevitable uncertainty was acknowledged, it was only invoked twice in the Panel's conclusions (*Panel Report*, p.58). Firstly, they declared that "it would be inappropriate to permit the associated risks [of petroleum production] on Georges", the risks in question being unspecified "significant impacts on the biota and fisheries of Georges". Secondly, the Panel concluded that "In considering risks to Georges Bank, the unacceptability of potential harm is the most important factor". Those were (and are) appropriate statements of sensible responses to uncertainty. In the Panel's evident view in 1999, although the full nature and severity of impacts were inevitably uncertain, the expected magnitude and probability of the effects were such as to require an on-going moratorium. Further research would, of course, help to clarify the issues and improve predictions of the effects, which might lead to re-consideration of the moratorium, but sufficient (albeit uncertain) knowledge was in hand to indicate that petroleum activity was inappropriate for Georges Bank. It was not a case of the evidence before the Panel suggesting that exploration and production were likely appropriate but that opening of the area should be deferred until research should increase confidence in that conclusion to the point that the remaining risk would be acceptable. The moratorium was not extended because of any lack of knowledge and Georges was not kept closed to petroleum activity to allow time for research.

Stantec's evident mischaracterization of this point led the authors astray and seems to have distorted much of their work. Most seriously, both reports contained lists of "Residual Issues" which too often comprised ideas about issues remaining to be examined by scientists, instead of which issues remain without effective mitigation. Indeed, in introducing what Stantec identified as "key decision factors" in the *Panel Report*, the authors actually defined "residual issues" as "remaining data gaps" (*Environmental Report* p. 4.1). It is no wonder that both reports missed their mark.

In the *Environmental Report*, Stantec raised an apparent criticism of the 1999 Review Panel by noting that it approached the moratorium extension as a yes / no question

(*Environmental Report* p. 1.4). The Panel did just that, of course, since that was their assigned task – though they provided an explanation of their recommendation which allowed the Ministers (themselves certainly faced with either extending the moratorium or not) to comprehend the subtleties of the issue. Stantec's objection, however, seems to have been that, by doing its job, the Panel placed itself in a position of putting more emphasis on socio-economic issues, "cultural values and preferences", with relatively less on "detailed and quantitative analysis of technical issues" (*Environmental Report* p. 1.4). That was a bizarre contention. In 1999, the Panel necessarily considered all technical issues, economic, social, ecological and engineering together. Being charged with an over-arching recommendation, it also considered values and preferences. Furthermore, and much to the credit of the Panel members, it did not fall into the common mistake of confusing that which can be quantified with that which is important. However, what additionally marked the thinking of the Review Panel was that, on technical issues, it relied on well-documented scientific advice, rather than oft-repeated pseudo-scientific propaganda.

By rejecting the Panel's approach, Stantec firstly distorted their task from a straightforward updating of the information available in 1999 into a dispute of the conclusions drawn by the Review Panel – an inappropriate stance for a contractor charged with providing unbiased advice on technical matters alone. Secondly, Stantec thereby implicitly declared its opposition to the values and preferences expressed by Nova Scotians a decade ago, which is an unfortunate position for an advisor. Thirdly and also implicitly, Stantec set itself against the scientific advice provided to the Panel in 1999 or at least those parts of the advice which were not consistent with the company's corporate conclusions. A report built on such preconceptions, as the *Environmental Report* evidently was, can only be regarded sceptically and with an expectation of severe bias. Unfortunately, close inspection of the document shows that that bias is all too evident.

Most curiously of all, Stantec chose to built its *Environmental Report* on a re-interpretation of the Precautionary Principle, which was deemed important enough to be featured in the Executive Summary (*Environmental Report* pp. E.4 & 1.5). The Principle is a matter for policy-making and had no relevance to Stantec's task, which included full and frank presentation of current scientific uncertainties but did not extend to offering recommendations for the action to take in the face of those uncertainties. In 1999, the Review Panel was charged with making such recommendations and they, appropriately, did so in a precautionary manner – erring on the side of avoiding harm, for all of the reasons that the Precautionary Principle and Precautionary Approach have been recommended to decision-makers for decades. Stantec, with no need to engage in the arena at all, nevertheless went ahead to articulate, or rather to attempt to articulate, a concept of "precaution" which it regarded as different from the one used in 1999. Exactly what that concept is remains unclear, though it evidently includes "monitoring and regular review", with examination of the effectiveness of existing precautionary measures, allowing adaptive management responses (*Environmental Report* p. 1.5). As

stated, there is nothing objectionable to those ideas, though they comprise what has been called "adaptive management" – but one component of a precautionary approach and not its entirety, let alone a substitute for the Precautionary Principle.

What is more curious is that Stantec should suppose that its proposal was in any way different to the approach followed in 1999, when the Panel recommended a twelve-year extension of the moratorium, after which it would presumably be reviewed once again. That Stantec saw its conception as something different suggests that the authors of the *Environmental Report* were guided by ideas other than those explicitly stated. Unclear though its nature remains, that conception was not some trivial, academic concern: It was, by Stantec's own admission, the foundation of their corporate biases. The *Environmental Report* specifically stated that its interpretation of the Precautionary Approach "is fundamental to the analysis contained in this report and provides the basis for the conclusions and recommendations" (*Environmental Report* p. 1.5) – conclusions and recommendations which, being in a supposed scientific document, should have been based on the literature and evidence reviewed and not on anyone's policy principles.

The suspicion must linger that Stantec's idea of "precaution" included the notion that Georges Bank should be opened to petroleum exploration, so that the monitoring intended to inform management of the Bank could be done *in situ*. If so, Stantec's corporate preconceptions did not so much predetermine the conclusions of the *Environmental Report* (a failing with parallels in too much scientific work) as they sought to predetermine the decisions of the Government of Nova Scotia concerning the moratorium. **A report thus biased can have no value as technical advice to decision-makers and should be given no credence.**

Preliminary Review of Environmental and Socio-Economic Issues on Georges Bank

Stantec's two reports were separate, stand-alone documents and they are primarily considered separately here. Some topics were, however, dealt with in both documents, occasionally with verbatim repetition of wording. To avoid further such duplication, some of my comments on the *Technologies Report* are here embedded amongst those on the *Environmental Report*.

That latter was a strange document: a compilation of information with no clear theme or focus, leading towards no conclusions – which did not stop its corporate author from stating surprisingly definite ones. Portions of its text vary so markedly in style and approach that they appear (and in one case were explicitly stated to be) the work of diverse hands, indifferently edited into a single report. So uneven was the product that it can only be addressed in a series of quasi-independent sections. I here do so, beginning with the environmental issues posed by offshore oil and gas activities that have been of greatest concern.

Seismic Surveys

Although assorted issues were raised during the public hearings of 1998–99, many of them outside the remit of the time, only five classes of environmental effects drove the Panel's decision: Those from seismic surveys, drill muds and cuttings, spills and blowouts, tainting (real or perceived), and lastly loss of access to fishing grounds. Of them all, the first was and remains the most problematic for Georges Bank. For ease of discussion, its effects are best separated into three types, respectively: immediately-lethal, sublethal (but physical or physiological) and behavioural impacts. They can further be subdivided into impacts on fish (serving also to represent those on invertebrate marine life) and on whales (with turtles and seals being perhaps less-vulnerable analogues of the cetaceans).

In its *Environmental Report*, Stantec made almost no mention of the lethal impacts of seismic on planktonic fish eggs and larvae nor those on the other (invertebrate) plankton (though they were rather obliquely noted in Table 6.1, p. 6.3). That is not as entirely inappropriate as it may appear: The lethal impacts of seismic have been endlessly discussed but there has been nothing new to say since well before 1999. A survey conducted with airguns as the sound source will kill small organisms very close to the guns (estimates of the maximum lethal range generally falling between 0.5 and 5 m) but the distances between survey lines and the depth of the plankton layer mean that the proportion of the populations affected is usually small – though not necessarily negligible. The only substantial risk of major loss would arise if a particular species happened to be concentrated near the depth of the guns at the time of the survey and that is very unlikely on Georges, where the swift tidal streams result in vertical mixing of the water.

Airguns do kill animals and it is better to avoid imposing death rates of even just a few percent on the larvae of species of economic importance, species at risk or those otherwise of special value. In the case of resource species, future catches are heavily dependent on the recruitment from occasional strong year-classes – with the good years being impossible to identify in advance. A survey that deleted even 5% or 10% of a strong year-class, by killing the fish during their larval phase, could in some cases reduce catches of the species in question by a similar percentage for the next decade or more. Hence, it has long been the practice off Atlantic Canada to schedule seismic surveys outside of spawning times. Unfortunately for such mitigation, on Georges Bank there is at least one commercial species with eggs or larvae in the water in each month of the year. Thus, if the accepted avoidance of spawning times is to be maintained, the moratorium might as well be: Seismic surveys cannot be performed on Georges without interacting with fish eggs or larvae and petroleum exploration cannot proceed without seismic surveys.

Larger animals with greater mobility, whether fish, whales or others, will only very rarely allow themselves to get within lethal range of an airgun array being towed through the

water, let alone an array that is firing, while "ramping up" protocols prevent overly-curious dolphins from being caught unaware by the first shot of a series. Accidents can happen but, given the now-standard practices of the industry, deaths of non-planktonic animals around airguns are too rare to be of concern. Benthic animals are entirely safe from immediate lethality: nobody could or would operate an airgun array within a few metres of the seabed. No such shallow waters exist on the Canadian portion of Georges Bank anyway.

Sublethal impacts, the most critical of which will lead to delayed mortality (through a reduced ability to feed, to avoid predators or both) or reduced reproduction, are at once far more complex and far less well understood than the immediately-lethal kind. In 1999, something was known of such impacts on whales but their prospect in fish and invertebrates (including benthic invertebrates) had barely been addressed. There has been some research since, including scattered efforts by DFO in Atlantic Canadian waters (which have not amounted to anywhere near the "substantial body of research" claimed by Stantec: *Environmental Report* p. 4.3), but the quantitative extent of losses (the proportion of a population affected), their severity and even their nature remain very poorly understood. Stantec's overview of the topic was largely confined to the generally-inconclusive local studies and its only reference to the broader primary scientific literature was a citation of a study of freshwater fish in the MacKenzie – a study which found little reason for concern in that particular case. No mention was made of the other published research which has shown damage to marine fish species from airgun sound (e.g. McCauley *et al*. 2003). Hence, Stantec's coverage of the sublethal impacts of seismic shooting was woefully incomplete. Major losses from such damage cannot yet be confirmed but neither can they be dismissed.

Knowledge of behavioural impacts of seismic surveys is more substantial, as it was in 1999 when this class of effect raised the greatest concern in 1999. For the whales, Stantec actually offered a substantial warning of the potential for harm, notably to the critically-endangered right whale, through masking of their auditory communications – leading to biological implications that are "not well understood". Other potential behavioural effects were also noted as "not well studied or understood" (*Environmental Report* p. 4.11). Stantec nevertheless wrote only of "short-term, localized" avoidance of seismic shooting by marine mammals. They did so without apparent consideration of the observations of bowhead whales (close relatives of right whales) in the Beaufort Sea, which tolerate high levels of seismic sound when feeding but avoid airgun sound sources by tens of kilometres when migrating (e.g. Richardson 2002). The right whales on Georges are on a migratory route, to or from the summer feeding grounds in the Bay of Fundy and on the Scotian Shelf, but whether or not they might be deflected off the Bank entirely by a survey there remains unknown.

As to the behavioural impacts on fish, Stantec offered a brief overview of the published literature (*Environmental Report* pp. 4.6–4.7) that was deficient primarily because the description of the effects was limited to short-term and rather local (tens of miles)

reductions (or sometimes increases) in fishery catch rates. Those are real and merit consideration but they could potentially be mitigated by planning and, if necessary, compensation. The biological consequences of the behavioural changes which emerge as changes in catch rate are, however, at once less evident, more serious and not discussed at all by Stantec. The extent of those effects remains very poorly understood as there has only ever been one full-scale study of the magnitude of the behavioural response (Engås *et al*. 1993a, b, 1996). While that concerned cod and haddock, species of prime concern on Georges Bank, it was conducted in the broad expanse of the Barents Sea and its results may not be directly applicable to the relatively-restricted extent of the Bank. For what it is worth, however, in that sole adequate experiment yet undertaken, seismic shooting caused the fish to move out of the study area (and an unknown distance beyond) – a minimum distance of some 35 km. If reproduced on the Canadian portion of Georges, such a survey could displace the fish off their feeding or spawning grounds or else simply drive them across the international boundary, away from Canadian fishermen and into American nets.

This is not new information: It was fully explained to the Review Panel in 1999 and appeared to have considerable influence on their recommendations. No subsequent research has emerged to alter the conclusions then drawn, the only substantial new study (Løkkeborg *et al*. 2009) serving to supplement but not materially change the information available a decade ago. Hence, Stantec might have been justified in skipping lightly over the topic but only if the lack of substantial new knowledge was presented as an absence of scientific reasons to alter the Panel's conclusions on this issue. By mischaracterizing behavioural impacts as only a matter of catch rates, however, the *Environmental Report* not only missed one of the principal negative consequences of lifting the moratorium but also failed to note that the technical grounds for extending it in 1999 remain unchanged today.

In contrast, Stantec did do a good job of summarizing the wide variety of concerns about potential effects of seismic which has emerged during the past decade, even if they were misleadingly termed "residual issues" (*Environmental Report* pp. 4.14–4.17). However, and most curiously, despite these various known or suspected effects of seismic having been one of the primary factors that shaped the Review Panel's recommendation in 1999, Stantec offered no mention of them whatsoever in the *Environmental Report's* Executive Summary, save in a list of seven "key issues" formerly considered by the Panel[3]. Meanwhile, in the main text, much stress was to put on mitigating measures which have been adopted since 1999 (*Environmental Report* p. 4.11–4.14) – though that discussion was counterbalanced by an account of a recent recommendation to weaken existing controls (*Environmental Report* pp. 4.8-4.9). In short, the overall impression of the effects of seismic that readers of the *Environmental Report* will be left with depends very much on which parts of the document they read.

[3] The possibility of seismic sound masking right whale communications was, however, noted in Table 6.1 of the *Report's* Section 6 summary (*Environmental Report* p. 6.3).

The enhancements to mitigation measures are real and valuable but insufficient to meet the particular requirements posed by Georges Bank. The current summation of the various advances is the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*, of 2007, but that is predicated on an assumption that seismic will proceed and seeks only to mitigate the consequences. It makes no provision for rejecting seismic surveys entirely in places where they would be inappropriate. The *Statement* calls for surveys to be planned to avoid all of: significant adverse population-level effects (or such effects on individuals of SARA-listed mammals and turtles), displacing or diverting such mammals or turtles, dispersing spawning fish or displacing most marine mammals (but only if it is known that that would have significant adverse effects). The *Statement* also requires the operation of a 500 m "safety zone" with provisions which should go far towards preventing immediate serious injury to whales, particularly SARA-listed species, and perhaps turtles – though only in daylight and clear weather. (The *Statement* includes some limited requirements for actions to be taken in low-visibility conditions but only in special areas.) That is all very well, and certainly much better than nothing, but it relies heavily on a proponent's environmental consultants concluding that a particular survey would have significant adverse impacts – something that long experience shows consultants are loath to do, as might be expected given their financial incentives. In the continued absence of such conclusions, the *Statement* boils down to little more than avoidance of known spawning grounds and known concentrations of SARA-listed mammals, plus the long-established measures to avoid short-range impacts on mammals. In short, the mitigation measures adopted to date do little or nothing to ameliorate the effects of seismic which led the Review Panel to recommend extending the moratorium in 1999.

Drill Muds & Cuttings

Another of the major concerns which led to extension of the moratorium in 1999 was the potential for discharged drill muds and drill cuttings to harm benthic biota. The practices in the North Sea in earlier decades led to a serious problem of large, toxic cuttings piles on seabed – the product of drilling with diesel-based muds. Those muds had long been disused before the 1999 Panel Review and debate had moved on to the acceptability or otherwise of various low-toxicity (but still oil-based) alternatives, given ever-advancing capabilities for cleaning the cuttings before discharge into the sea (or else either re-injecting them or shipping them ashore for processing). The use of water-based muds ("WBMs") had been seen as an attractive option, wherever it was a technically-feasible (as it likely would be on Georges Bank), despite the much larger quantities of mud discharged into the ocean – WBM being typically dumped at sea, whereas the oil-based alternatives are recycled and only a coating on the cuttings enters the water. That comfortable conclusion was, however, upset when a research program led by Dr. Cranford at BIO (a program specifically funded in connection with the original Georges moratorium) looked at the effects on scallops of the principal constituents of WBMs: barite (a dense but non-toxic mineral) and bentonite (a special form of clay). To

the surprise of all concerned it was found that the animals are remarkably sensitive to both materials[4].

Thus, by the time of the 1999 Panel Review, the issue was less the toxicity of the traces of oil-based muds discharged as a coating on cuttings (be the oil used a "low-toxicity" type, an "alternative" composition, a "synthetic" or anything else) and more a matter of the large quantities of barite and bentonite in the bulk dumps of WBM that would be expected if there was any drilling on Georges. Given the strong tidal streams, that material would usually be swiftly dispersed on the Bank – lowering concentrations but expanding the area temporarily affected. The complex balance between concentration, extent and the sensitivity of the scallops means that the degree of negative impacts cannot be guessed but must be calculated. The necessary calculations were done, again by scientists at BIO, using a "Benthic Boundary Layer Transport" ("BBLT") model. The results from that work, available in 1999, pointed towards neither massive losses of scallops nor inconsequential effects but rather something intermediate. The predictions were sufficient for the Review Panel to comment: "For drilling wastes discharged from a rig on or near Georges, the probability that significant, harmful effects would occur cannot be discounted" (*Panel Report* p. 35) and to conclude: "Drilling muds and other discharges pose some hazards to marine life and productivity" (*Panel Report* p. 57)[5].

For that conclusion to change, there would have to be either evidence that the sensitivity of the scallops had been misunderstood (which is very unlikely to be the case), a solid argument that bulk dumps of WBM would not be discharged during drilling on Georges, new calculations showing that previous conclusions about the speed and extent of the dispersal of the mud were wrong, or some combination of those. Stantec offered nothing of the kind and thus gave no reason for amending the Review Panel's conclusion about muds and cuttings.

What Stantec did provide was a dozen pages (*Environmental Report* pp. 4.17–4.28) of largely irrelevant and specious discussion. It included a statement that modern synthetic-based muds ("SBMs") are less toxic than previous oil-based alternatives (*Environmental Report* p. 4.18) – even though the problem identified in 1999 was not with small quantities of oil but with large amounts of barite and bentonite in WBM[6]. There was a

---

[4] The always-groundless claim that scallops are uniquely sensitive to barite and bentonite was soon dismissed (cf. Barlow & Kingston 2001). So far as is known, the many filter-feeding species amongst the benthos are all variously sensitive to barite and bentonite, though few of them have yet been properly tested.

[5] Stantec have claimed that the Panel identified uncertainty about whether discharge of muds and cuttings would have significant harmful effects (*Environmental Report* p. 4.19). If saying that such effects "cannot be discounted" constitutes an identification of uncertainty, then Stantec's claim is not groundless.

[6] The toxicity of discharged drill muds is of questionable relevance anyway. The immediate lethal effects of oil on cuttings are likely to be confined to an area very close around the discharge pipe. The effects of ecological concern (if any) must be those which act over a larger area, where the muds will be diluted far below toxic levels but where they may still alter the structure of the ecosystem by weakening certain

suggestion that Dr. Cranford's research found the effects of muds and cuttings to be localized (*Environmental Report* p. 4.19), when it was that research which, in combination with the modelling, led to the estimates of effects which the Review Panel saw as posing hazards. There was a vague appeal to dispersion by the strong tidal streams of Georges, coupled to results from early monitoring efforts in the 1980s, in an apparent attempt to counter the results of BBLT calculations that were provided to the Panel (*Environmental Report* pp. 4.19–4.20) – in direct contradiction of Stantec's own heavy reliance on BBLT (*Environmental Report* p. 4.21–4.22). There was a misleading juxtaposition of Dr. Cranford's discovery that scallops are so sensitive to bentonite and barite with an observation that the (unrelated) toxic effects of drill muds are confined to areas within 500 m of drilling rigs off Nova Scotia, along with confirmation of the obviously-greater dispersal of WBMs than SBMs (off Brunei!) and the equally-obvious greater dispersal of materials in shallow, energetic areas compared to deeper, quieter waters. From that series of non sequiturs, Stantec somehow drew the conclusion that "the ecological consequence of acute interactions from drilling muds and cuttings discharges is expected to be low" (*Environmental Report* p. 4.21).

BBLT modelling was presented by Stantec as a new development following the Panel Review (*Environmental Report* p. 4.21), when not only had it been developed years earlier but it was first used to study dispersal of drill wastes in a study specifically designed in support of the Panel's process. More recent applications of the model were mentioned (*Environmental Report* p. 4.21) but no suggestion was offered that those have contradicted anything in the scientific advice placed before the Panel. There was an admittance that subsequent research in Europe has shown that some other bivalves display similar sensitivity to scallops (*Environmental Report* p. 4.23), though not of the possibility that these species may actually be comparatively insensitive by the standards of yet other filter-feeding benthos and are remarkable only for being the first examined for the sublethal effects of barite and bentonite. There was, however, space to note that fish and crabs do not suffer equivalently (*Environmental Report* p. 4.23), which was never to be expected. Page 4.24 of the *Environmental Report* was devoted to bioaccumulation, though that does not seem to have been an issue that the Review Panel saw fit to comment on and it is not one that would be expected to be a major issue if drilling were permitted on Georges Bank.

When it came to possible mitigation measures, Stantec offered stricter limits on the amount of oil discharged on cuttings and the like (*Environmental Report* pp. 4.27–4.28), none of which have any relevance to WBM discharges. Apparently, attempts have been made, off Nova Scotia, to replace barite with brine (*Environmental Report* p. 4.27),

---

species in their competition with others. Aspects of discharged chemicals quite other than those that create toxicity may predominate at such ranges from a drill rig (as indeed the effects of barite and bentonite on scallop gills illustrate). There is, as yet, no reason to think that discharges of modern forms of oil-based muds have any less broadly-extensive ecological effects than the older types did, nor indeed any reason to dismiss the possibility that they are more harmful.

which might actually help with the primary drilling-waste problem on Georges, though it was done to reduce discharge of mercury.

Amidst that stream of intermingled irrelevancies purportedly concerning the drilling-wastes issue, Stantec offered much comment based on Environmental Effects Monitoring ("EEM") of offshore-petroleum activities, particularly in Atlantic Canadian waters (*Environmental Report* pp. 4.23–4.27). While that was represented as showing that the effects of drill muds and cuttings are at most minor, it also touched on other impacts and thus merits its own section.

Environmental Effects Monitoring

In both reports, Stantec appeared to place great store by the results of EEM of offshore-petroleum activities, even including within the conclusions and Executive Summary of the *Technologies Report* a statement that none of the activities to date off Atlantic Canada "have demonstrated population level effects to the marine ecosystem, or on species at risk and their critical habitat" (*Technologies Report* pp. E.2 & 3.9). Nothing in the text of that *Report* supported any such statement but it was said to be based on "the results of numerous environmental effects monitoring" and backed by citations of a draft report apparently in preparation by CNSOPB and a completed report prepared by Hurley & Ellis (2004).

In the *Environmental Report*, Stantec worded essentially the same statement as "none of [the exploration and production activities off Atlantic Canada] have demonstrated, through environmental effects monitoring [*or:* based on the results of EEM], population level effects to the marine ecosystem, or on species at risk and their critical habitats" (*Environmental Report* pp. E.4 & 6.6). In contrast to the *Technologies Report*, however, the *Environmental Report* also provided further detail, noting that Hurley & Ellis (2004) "determined that changes in the diversity and abundance of benthic organisms were most common within 50 to 500 m of drill sites" and that benthic communities returned to their baseline conditions within a year after drilling ceased (*Environmental Report* p. 4.23, cf. p. 4.25). Over page, Stantec's claim became that any toxic effects from drill muds and cuttings "have been shown to occur only in the immediate vicinity of the drilling rig […] i.e. within 500 m" (*Environmental Report* p. 4.24). The information from the EEM was described as a "key advancement in the past decade" (*Environmental Report* p. 4.25)[7], that information including "no significant effect on the marine environment" from the three major production projects off Newfoundland – monitoring around the Terra Nova drilling specifically having "demonstrated no significant effects on fish health and fish habitat". Amplifying, or perhaps contradicting, that conclusion, Stantec also declared that changes to benthic communities were not severe and were likely mainly caused by organic enrichment from biodegradable SBM (*Environmental Report* p. 4.26). Some

[7] Though it is not clear why the conclusions were seen as new. EEM programs in the North Sea and on the U.S. side of Georges Bank had generated very similar results in the 1980s.

"progress toward […] recovery appeared to occur within one to five years (*Environmental Report* p. 4.26).

I will not here dispute any of those summaries of the findings of past EEM programs. Not one of them, however, need be given any credence at all.

Everything in the ocean is constantly varying, in space as well as time. Meanwhile, measurements made of any but the simplest marine variables will depend as much on the sampling instruments and the protocols used as they do on the state of the ocean and its biota. Thus, effective monitoring programs must be carefully designed, with standardized techniques, and tightly controlled to ensure that the designs are followed, else the data obtained would not be mutually comparable (across space and time) and no conclusions could be drawn. That much is well understood and it may be presumed that these strictures were carefully observed in each of the petroleum-oriented EEM programs off Atlantic Canada. However, a consequence of this dependence on rigid designs is that monitoring cannot utilize occasional observations. It can only detect what it was designed to look for and the failure to detect something may mean nothing more than that the designers chose not to look for it – either because they did not think of it, they did not think it worth monitoring or they did not want to find it.

That is a particular problem for Stantec's declaration of the absence of "demonstrated population level effects". The mobility of water means that the great majority of marine populations extend over wide areas – the width of a bank in some cases, fully across oceans in others. EEM programs, in contrast, are almost invariably (and properly) confined to the near vicinity of the monitored development. Monitoring for changes in whole populations would require very different kinds of surveys. Thus, Stantec's claim is doubtless right: Atlantic Canadian offshore EEM has not detected any population-level effects. It has not done so because it was never designed to be capable of detecting such effects. Its failure to achieve the impossible says nothing whatsoever of whether or not population-level effects have occurred.

That is not a failure of the EEM programs but rather of Stantec's claims concerning them. EEM is not designed to look for population-wide effects because, when ecological trends are seen over wide areas, it is quite certain that they have multiple causes and determining the extent to which one particular cause (such as an offshore petroleum project) contributed to the observed trend is difficult to the point of impossibility. The case of the Newfoundland oilfields illustrates the point: The most economically and socially important marine population in the area, by far, is the Grand Banks cod. That is routinely monitored (by DFO) and, famously, it has not recovered from past depletion despite nearly twenty years of draconian restrictions on fishing. It would be foolish to suggest that petroleum activities on Grand Bank have been a primary cause of that failure to recover but all that monitoring programs can reveal is the continued depression of the cod. If reliance were to be placed in monitoring, as Stantec seems to wish, then one would have to conclude that a suite of causes, including the impacts from oil exploitation,

have together had a massive population-level effect. It would be wrong to draw the conclusion that all offshore petroleum activity should therefore be terminated but it was disingenuous to declare that population-level effects have not been observed simply because they have not been detected by EEM programs that had other objectives, when those effects have been all too clearly seen by the monitoring programs which were designed to look population-wide.

There is a second and even more pervasive problem with Stantec's claims: The process of academic scientific research presumes that hypotheses are developed and tested – only those which pass the tests being accepted as descriptions of empirical reality (tentatively accepted, as further testing may yet prove them false). Other hypotheses are not necessarily rejected as being untrue but are set aside, pending supporting evidence being found. The logic is analogous to, but different from, that used in criminal trials, where the accused is presumed innocent until proven guilty, a "not guilty" verdict being not a confirmation of innocence but merely the absence of confirmation of guilt. When generating scientific advice for policy-makers, however, the onus is very often different again. Unlike academic science, it is rarely a matter of testing an interesting hypothesis and is often more about confirming that some undesirable outcome has not happened or will not happen. That was the orientation of Stantec's interest in EEM, with their statements that this or that effect had not been seen.

Unfortunately, the statistical analyses used to tease indications of underlying trends out of inevitably variable data, without being misled by the chance variations, are analyses developed for use in academic research. Thus, they are intended for confirming that something has happened (usually with a maximum 1-in-20 probability of an error – the error being that a "detected" event did not really happen and only chance variations in the data caused confusion). Such tests can only show that something happened. They are incapable of showing that it did not happen – which is the form of conclusion that Stantec, along with the authors of the reports that they cited, sought to draw from the analytical results.

In order to support a conclusion of an absence of an effect (an effect that an EEM program was designed to look for), it is necessary to examine "statistical power" – which is heavily dependent on the sampling design, particularly the amount of sampling, meaning that it is really the "power" of the EEM program, not that of a specific analysis. Without attempting to define "statistical power" here, when it is considered it usually takes the form of an estimate of the probability that some effect would have been detected, if it had happened – the probability varying with the assumed magnitude of the effect. For example, it might be said that a particular EEM program would have had a 75% chance of detecting a 50% decline in the growth rate of scallops 1 km from a drill site, if such a decline had occurred.

I do not claim intimate knowledge of the EEM programs conducted off Atlantic Canada but information on their "statistical power" is sketchy at best. Hurley & Ellis (2004), for

example, described the "power" of the benthic-monitoring components of the *White Rose* and *Terra Nova* EEM programs as "good", which is scarcely reassuring, but otherwise said little more about "power" than that it was "limited" in many of the programs that they reviewed. The latter does seem likely. Indeed, examination of some EEM designs suggests that they were so lacking in "power" that they never had much hope of detecting anything – which, sadly, may have been their designers' deliberate intent.

Without both adequate "statistical power" and appropriate documentation of that adequacy, which do not appear to both be available for any Atlantic Canadian offshore EEM program, reports that nothing was seen are simply empty: Such monitoring cannot distinguish the lack of an effect from the monitor's failure to detect what was happening in the sea.

A third problem arises with Stantec's invoking of a lack of "significant effects" since the word "significant" has two quite different meanings in the context of EEM. To the policy-maker, as to much of the public, a "significant effect" is one that matters in some way: a 10% decline in scallop landings, perhaps, or the death of a single right whale. In contrast, to a statistical analyst, a "significant effect" is one detected with a probability less than some pre-selected level (usually 1-in-20) of it having occurred by chance alone, through random variations in the data. When massive amounts of data are collected, quite tiny changes ("insignificant" in the common English meaning of the word) can be deemed "significant" in the statistical sense, since the large quantity of data allows those changes to be detected in the face of the inevitable variability. Data collection offshore is, however, expensive and petroleum companies have little incentive to pay for monitoring that would detect inconsequential impacts on marine ecosystems. Thus, the common situation with EEM is that monitoring programs are unable to detect statistical "significance" even when changes have occurred in the ecosystem that are large enough to be highly "significant" in the sense usually understood by non-scientists.

Hence, Stantec's declaration that monitoring has "demonstrated no significant effects" was entirely meaningless. By not explaining which kind of "significance" was intended, the declaration lost all meaning. It seems likely, however, that what was demonstrated was an absence of statistical "significance", which means nothing more than that there was insufficient sampling to achieve the "statistical power" needed to detect the changes which had occurred. For the demonstration to have had any greater meaning would have required, first, that consultations with stakeholders and consideration by ecologists established the degree of impact that mattered (the degree that was "significant" in the common sense), second, that an EEM program was designed to have sufficient "statistical power" to detect that degree of impact (should it occur) with an acceptable level of confidence (perhaps a 10% chance of failing to detect the effect, if present), third, that the monitoring be conducted according to that design and, fourth, that the data gathered show no statistically "significant" effect. In the absence of all of those steps, each adequately documented, declarations of a lack of "significance", such as those offered by Stantec, are mere empty words.

Spills & Blowouts

The third major concern in 1999 was over unlikely but potentially catastrophic large spills and blowouts, along with the lesser but more probable effects of minor spills. Stantec offered a multifaceted response, downplaying the importance of such events to anything but seabirds, claiming that the occurrence of blowouts and spills from offshore-petroleum activities is declining, relating the volume of spilt oil to that released by natural seeps and holding out the promise of clean-up capabilities. None of those should be taken seriously.

What Stantec did not do, indeed could not do in any very useful way, was to comment on lessons learned from the two major offshore accidents of 2009–10, *viz.* the blowouts on Australia's Montara field and of the *Deepwater Horizon's* well in the Gulf of Mexico. A formal inquiry into the former has been completed but the Government of Australia has yet to release the resulting report, while the *Deepwater Horizon* tragedy was on-going when Stantec completed its reports. Their authors did at least note their inability to take any account of events in the Gulf but they failed to even mention the Montara disaster. Suffice to say that new perspectives on offshore blowouts and spills will be forthcoming in the next few years which will require revision of Stantec's discussions.

Effects on Biota

Turning to what was said in the *Environmental Report*: For the effects of spilt oil on plankton, Stantec relied on a single cited study of one oil spill – a study which failed to detect much of anything, which is hardly surprising given the variability of planktonic communities. Stantec went so far as to declare that "it is difficult to demonstrate that spills and releases have any irreversible effects on planktonic communities" (*Environmental Report* p. 4.49). Indeed it is but one could go further and could confidently declare that spills do not have irreversible effects on plankton. That, however, should be no reassurance: Had the Cold War become hot, compelling NATO's navies to use their nuclear depth charges when hunting Soviet submarines over Georges Bank, the resulting explosions and radiation would have been horribly damaging to marine life but would not have done anything to the plankton that would not have been reversed within a year or so. Spilt oil, even that from a massive tragedy such as the *Deepwater Horizon* blowout, would be far less harmful but still entirely unacceptable – and all without irreversible effects on plankton. Reversibility is simply not a relevant criterion.

For fish eggs and larvae, Stantec admitted to negative effects but concluded "high natural mortality rates make it difficult to determine the effects of an oil spill" (*Environmental Report* p. 4.49). Indeed they do. However, a 10% loss of larvae is still likely to lead to approximately a 10% reduction in recruitment of the year-class, whether that is detectable or not. Whether it would matter is an entirely unrelated question – importance and detectability being quite different things. In some cases, even the complete loss of a year-class would not matter but, in others, minor losses would be serious. Any reduction in the strength of the massive 2003 year-class of Georges haddock, the year-class which almost

alone has been the saviour of the groundfish fisheries on the Bank, would have had massive economic consequences – even though such a loss would have been entirely undetectable. As with reversibility, detectability is not relevant here.

For adult fish, Stantec pointed to the lack of an effect of the *Exxon Valdez* spill on the local pink salmon resource (*Environmental Report* pp. 4.49). They neglected, however, to mention the collapse of the herring in Prince William Sound which has been attributed to the spill (Thorne & Thomas 2008).

Stantec correctly noted that seabirds are the most vulnerable of all marine animals to surface oil and acknowledged the potential for high morality. For the birds, the only ameliorating arguments offered were that no "at risk" bird species occur on Georges (small comfort for the populations of species which do use the area) and that "recovery plans" would be implemented in the event of a spill or blowout (*Environmental Report* pp. 4.51–4.52). Just what such a plan could do to reduce losses of birds oiled offshore was not stated and remains a mystery to this writer.

Incidence & Magnitude of Spills & Blowouts
Stantec's claim that the incidence of blowouts and spills from the offshore-petroleum industry are declining was made in both reports (*Environmental Report* pp. 4.43–4.45, 4.47; *Technologies Report* p. 2.36, cf. p. 2.40), citing a recent compilation of statistics by Etkin (2009), which can be accepted for the time being as authoritative (though incomplete and presented as an overt exculpation of the petroleum industry). Specifically, both Stantec reports claimed a reduction in average annual spillage from petroleum industries of 46% from 1997 to 2007 and 77% from 1969 to 2007. Those percentages were drawn straight from Etkin's (2009) executive summary, though it should be noted that they are really decreases between the annual averages for 1969–77 or 1988-97 (respectively) and that for 1998–2007. It should also be understood that the underlying data represent accidental spillages of oil (not natural gas) into U.S. waters (both federal and state) only, including all sources of accidental spills but excluding such deliberate discharges as produced water (Etkin 2009). They are neither global nor Canadian statistics, though one might expect that accident risks in Canada have followed similar trends over time to those seen in the United States.

It was, however, unfortunate that Stantec examined (or at least drew from) only Etkin's (2009) summary and not the content of his report. The latter provides records of the offshore petroleum and tanker industries separated out from those of other sources of spilt oil, which would seem more relevant to questions surrounding the Georges Bank moratorium. The relevant figures (all units in barrels) are[8]:

[8] Source of data: Etkin (2009), Table 56.

Spill Source	**1969–77**	**1978–87**	**1988–97**	**1998–2007**
Platforms	25,858	1,344	1,814	1,273
Pipelines	4,482	3,462	8,127	2,614
Supply Vessels	95	245	48	10
OFFSHORE TOTAL	30,435	5,051	9,989	3,897
Tank Ships & Barges	224,322	113,239	65,079	9,027

Those numbers suggest great progress, especially in tanker safety, with the decline in the volumes spilt by the offshore-petroleum industry appearing even faster than the overall rates quoted by Stantec. The lack of much reduction in the volume spilt by the offshore industry between 1978–87 and 1998–2007 is, however, a warning and an indication that the story is not quite so simple as it appears at first glance. Indeed, the numbers are very strongly influenced by a few, major incidents. Those have been[9]:

1968	*Mandoil II* spill	300,000 bbls
1968	*Pegasus* spill	228,500 bbls
1969	Santa Barbara blowout	100,000 bbls
1969	*Keo* spill	209,524 bbls
1970	Main Pass blowout	65,000 bbls
1970	South Timbalier blowout	53,095 bbls
1970	*Gezina Brovig* spill	112,000 bbls
1971	*Texaco Oklahoma* spill	225,000 bbls
1975	*Spartan Lady* spill	142,857 bbls
1976	*Argo Merchant* spill	183,333 bbls
1976	*LSCO Petrochem* spill	109,952 bbls
1979	*Burmah Agate* spill	254,762 bbls
1984	*Puerto Rican* spill	100,000 bbls
1989	*Exxon Valdez* spill	268,332 bbls
1990	*Mega Borg* spill	119,048 bbls

Subtracting those numbers from the values given above yields a residue exclusive of the few major events:

[9] Source of data: Etkin (2009), Tables 20 & 27. The table presented here includes all blowouts which released more than 12,000 bbls (each of which released more than 50,000 bbls) and all tanker spills of 100,000 bbls or more.

Spill Source	1969–77	1978–87	1988–97	1998–2007
Platforms	1,625	1,344	1,814	1,273
Pipelines	4,482	3,462	8,127	2,614
Supply Vessels	95	245	48	10
OFFSHORE TOTAL	6,202	5,051	9,989	3,897
Tank Ships & Barges	115,137	77,763	26,341	9,027

It is evident that the tanker industry has indeed achieved both a remarkable reduction in major accidents since the mid-1970s, with only four large spills in U.S. waters since then and none at all since 1990, and a dramatic and rather steady reduction in the combined volume of minor spills – though tanker accidents continued to be the largest source of U.S. oil spills through to 2007. Contrary to the claims made by Stantec, however, there is no evidence of any trend towards a reduction in volumes spilt by the offshore industry, once the three major blowouts of 1969–70 are excluded. The elevated volume of oil spilt during 1988–97, which upset what might otherwise have seemed a steady decline, was largely a result of multiple pipeline spills: twelve, totalling 31,204 bbl, in 1988, twenty four, totalling 19,937 bbl in 1990, six, totalling 9,184 bbl in 1994 and twenty, totalling 10,028 bbl in 1997 – in addition to more moderate amounts in the other six years of the decade[10]. There is nothing obvious in the data presented by Etkin (2009) to suggest that this was more than a chance coincidence in timing. Indeed, had the data been grouped by calendrical decades, 1980–89 would have seen 62,711 bbl of pipeline spills and 1990–99 72,060 bbl, which would have gone far towards smoothing out the peak in Etkin's (2009) presentation of the data.

It may be noted in passing that this lack of any evident improvement in the performance of the offshore petroleum industry would not be altered by re-calculating the volumes spilt in per-unit-production terms, since U.S. offshore-oil production has been remarkably steady over the past four decades:

[10] Source of data: Etkin (2009), Table 7.

	1969–77	**1978–87**	**1988–97**	**1998–2007**
bbls spilt by offshore industry	30,435	5,051	9,989	3,897
Spilt per bbl produced[11]	0.0000089	0.0000015	0.0000040	0.0000012
Back-calculated production (bbls)	3,419,662,921	3,367,333,333	2,497,250,000	3,247,500,000
bbls spilt ex. major blowouts	6,202	5,051	9,989	3,897
Spilt per bbl produced ex. major blowouts	0.0000018	0.0000015	0.0000040	0.0000012

Until the spring of 2010, major blowouts in U.S. waters at least appeared to have been a thing of the past, with none since 1970. The *Deepwater Horizon* disaster, however, spewed an estimated 4,900,000 bbls – more than ten times as much as any one other U.S. spill. Even if that one event proved to be the only platform spill of 2008–2017 (a most unlikely occurrence), the annual average for the decade would still be 490,000 bbls – which would dwarf not only all previous decadal averages for U.S. platform spills or U.S. offshore-petroleum spills generally but even those for U.S. offshore and tanker spills combined. The *Deepwater Horizon* incident alone, during the few months that the blowout continued, spilt more oil than Etkin's (2009) annual averages for all U.S. sources combined during 1978–87 or 1998–2007 and about as much as the annual average for 1988–97. In short, and in direct rebuttal of Stantec's facile claim that the recent Montara and *Deepwater Horizon* blowouts "do not negate the fact that the overall trend of spills and blowouts is decreasing" (*Technologies Report* p. 2.36), the annual spillage by the offshore petroleum industry in the United States has <u>not</u> been reduced since the late 1960s, neither in its rare major blowouts nor in its on-going series of minor events[12]. The Canadian industry is too small to generate useful estimates of the frequency of such rare

---

11 Source of data: Etkin (2009), Table 23.

12 The lack of any downward trend in blowout frequency is hardly a novel observation. It was previously noted, for the period 1960–1996, by Skalle & Podio (1998).
Stantec picked up on a comment in Hurley & Ellis' (2004) report, itself based on an unpublished communication, to the effect that there had been no blowout anywhere in the world that released >10,000 bbl after 1997. Unfortunately, that was used carelessly in the *Environmental Report* (p. 4.45), where it became a claim that there had been no such blowout in the 20 years preceding the *Deepwater Horizon* disaster – thus denying the existence of Australia's Montara blowout of 2009. The best that can be said of Stantec's claim is that it revealed a woeful deficiency in report editing, even if it did not necessarily reveal a remarkable ignorance of the topic at hand.

events and too young for long-term trends to be discerned but Stantec has offered no reason to think that the risks are declining here, any more than they are in U.S. waters[13].

Natural Seeps

Linkages between oil spills and natural seeps (e.g. *Environmental Report* p. 4.48) seem to be a favoured theme among apologists for the petroleum industry, which is curious considering that the effects are utterly different and hence the comparisons supremely irrelevant. Seeps are numerous and widely dispersed, each slowly but continuously leaking small amounts of hydrocarbons into ecosystems composed of biota adapted to such inputs. Spills and blowouts, in contrast, occasionally place large amounts of oil or gas, concentrated in time and space, into ecosystems that are not usually adapted to receive even small quantities and which therefore largely comprise species for which the hydrocarbons are toxic. Seeps are therefore energy sources for specialized biological systems, whereas spills are damaging to, even destructive of, the ecosystems which receive them.

Stantec quoted a global quantity of seeping oil of 4.2 to 14 million barrels annually, citing early sources (*Technology Report* p. 4.48). Those figures were in fact drawn from Etkin (2009), who provided them when introducing the topic but corrected them later in his text. The accepted estimate (used by the U.S. NRC and by GESAMP) is 0.14 to 14 million barrels (Etkin 2009) – an enormous range of uncertainty. Stantec also quoted an estimate of the volume of oil spilt at 0.9% of natural seepage – again derived from Etkin (2009), who explicitly intended that as an estimate for U.S. waters specifically. That figure relied on an estimate of seeps into U.S. waters of 1.1 million barrels, which would obviously be inconsistent with a global figure of 0.14 million. Etkin's (2009) estimate of 0.9% was, however, only for the decade 1998–2007 and only for spills from exploration and production. The total of all spills into U.S. waters during 1998–2007 was estimated at 17% of an annual seep estimate of 1.1 million barrels, down from 57% in 1969–77.

---

[13] There are, of course, other sources of statistics on accident rates in the offshore industry. The *Environmental Report* (pp. 4.47–4.48) offered a different set of numbers for tanker spills from Etkin's (2009) but one which again showed substantial reductions in accidents.
In 1998–99, the Review Panel heard a figure of one blowout per 180 wells drilled. Stantec, in contrast, suggested one deep blowout per 3,600 exploration wells (though that was confusingly presented as one per 1,800 years of drilling two wells per year: *Environmental Report* p. 4.45), with blowouts releasing large quantities being rarer still. Those figures were credited to Hurley & Ellis (2004), who indeed presented them but gave few indications of their source. A more authoritative compilation is available as IAOGP (2010). For North Sea-standard operations, that source indicates one shallow gas blowout per 400 exploratory or 517 development wells, with the risk of deep blowouts varying between one per 455 high pressure / high temperature exploratory gas wells and one per 20,833 normal development oil wells. The Stantec 1-in-3,600 risk falls between IAOGP's estimates for deep blowouts in normal exploratory wells drilled for oil and those drilled for gas.
IAOGP's (2010) tables also allow calculation of risks of blowouts during routine production operations.

Clean-up Capabilities
Should a substantial spill ever occur on Georges, the question of what to do about it would swiftly arise. There is an array of clean-up technology, including booms, skimmers, absorbents and the like – most of which have been available for decades. There is on-going research looking for better methods but Stantec was unable to identify any advances since 1999 that are ready for use (*Technologies Report* pp. 2.38–2.40; *Environmental Report* pp.4.53–4.54). The existing technology is certainly valuable in inshore waters but there continue to be no viable means for dealing with spilt oil offshore, save for the spraying of dispersants, not even in the Gulf of Mexico (as seen very publically following the *Deepwater Horizon* disaster) let alone on Georges Bank. Dispersants have their place amongst the tools for dealing with spills, despite on-going concerns that they only make a bad situation worse, even if their primary benefit is as a public-relations tool, minimizing the bad publicity from the oiling of beaches. Stantec discussed them as an option on Georges, going so far as to describe them as "likely to be effective in the Georges Bank area" (*Technologies Report* pp. 2.39–2.40; *Environmental Report* pp.4.53–4.54). Yet, the primary concern after a spill on the Canadian side of the Bank would be for fishery resources and other species of the water column and seabed. Dispersing surface oil downwards into the sea would thus seem the worst of all options – even though it would be the only viable one available, other than letting nature take its course, while closing the fisheries temporarily to ensure that no tainted product reached market[14].

That Stantec could suggest the use of dispersants is itself troubling, hinting as it does that elements within the petroleum industry are already thinking of hiding any spills on Georges Bank by spraying chemicals and spreading surface slicks downwards to the fish and their food.

<u>Other Impacts</u>
Stantec also addressed a number of other issues in its *Environmental Report*, including produced water, atmospheric emissions and more. Sufficient has been said here on the major concerns, however, that I will pass over the others – save for noting that, in touching on the loss-of-access issue, Stantec returned to the hoary old myth of a comfortable "coexistence" of the fishing and petroleum industries in other seas (*Environmental Report* p. 4.57). While there is a place for both around the North Atlantic and specifically in the waters off Nova Scotia, they proceed (outside of particular moratorium areas and the like) in an asymmetric "coexistence" which sees the petroleum

[14] Stantec briefly discussed the issue of tainting of seafood following a spill or blowout and noted the increased sensitivity of consumers to such an incident (*Environmental Report* p. 4.50). Should there be a spill, actual tainting of seafood in the supply chain is unlikely, not least because DFO would likely respond as NMFS did in the case of the *Deepwater Horizon* disaster and would close to fishing not only the affected area but also a buffer zone. However, experience in 2010 showed that many consumers lacked either understanding or trust and avoided seafood from unaffected portions of the Gulf of Mexico (and, in some cases, from quite other seas). Such perceptions of tainting can be as economically damaging to the fisheries as are any of the real effects of offshore petroleum exploration and production.

industry operate wherever and however it perceives a prospect for viable production, while the fishing industry cedes its long-held grounds and works where the petroleum industry does not. That both industries will continue to exist off Atlantic Canada is undoubted, as both do in the North Sea and in the Gulf of Mexico – the original region for offshore oil production and the most mature of them all. Yet to understand the "coexistence" of the two industries in the Gulf, one needs to remember that successive Governors of Florida and that State's Congressional delegations have long maintained a steadfast refusal to allow petroleum activities in the eastern Gulf. Even when a decision of the Bush administration (which has since been rescinded) led to a broad opening up of offshore areas previously closed to petroleum exploration, the waters west of Florida remained shut. In wake of the *Deepwater Horizon* tragedy, it is certain that the oil industry will be left to "coexist" off Louisiana but will be kept away from the fishing grounds east of Cape San Blas for the foreseeable future.

Knowledge of the Marine Biota of Georges Bank

Stantec devoted a considerable fraction of their *Environmental Report* (pp. 2.25–2.50) to what is known of the Georges Bank ecosystem, though the text tended to drift between describing what is known as of 2010 and how much of that has been newly discovered since 1999 – or perhaps how much is now known but was not mentioned in the 1999 *Panel Report*. Unfortunately, much of that material was compromised by a reliance on an unfinished (and hence confidential) draft report prepared by DFO which was not accepted by (and arguably was rejected by) the Department's peer-review process. Founding the Stantec report on such a draft left it with no foundation at all.

Much of the material had limited relevance to any reconsideration of the 1999 moratorium-extension decision anyway, since it only represented a series of incremental advances in scientific understanding. Indeed, Stantec seems to have seen little of significance in any of it since the description of the biota received no comment whatsoever in the *Environmental Report's* Executive Summary – not even for topics where the main text did note a relevant advance. One such was that three, or maybe even four, whale species that are accounted "at risk" occur on Georges, not simply the right whale which was noted in 1999 (*Environmental Report* p. 2.44). Another was sea turtles, which were little recognized in Canadian waters until recent years – though it must be said that the concentration of leatherbacks is known from the Scotian Shelf, rather than Georges, while loggerhead only occur on the Bank as rare strays (*Environmental Report* p. 2.45–2.46). A third example concerns cold-water corals (*Environmental Report* p. 2.40–2.42). Those have long been known from the deep waters around Georges, and the re-birth of local scientific interest in the animals can be dated from the publication of fishermen's reports by Kenchington & Halliday (1994), but it was not until the First International Symposium on Deep-Sea Corals was held in Halifax in 2000 that the topic drew close attention and only in 2002 was a coral-conservation area delimited within the Moratorium Lands. Indeed, during the entire Panel Review process leading to the 1999 recommendation to extend the moratorium, the focus was overwhelmingly on Georges Bank itself, largely to the exclusion of the rest of the moratorium area. Thus, the corals

and other deeper-living biota of the Northeast Channel, as well as their habitats, were barely considered a dozen years ago. Stantec's *Environmental Report* did little to broaden that perspective.

Socio-Economic Environment of Georges Bank

The existing socio-economic environment, into which petroleum activities might be placed if the moratorium were allowed to lapse, includes a wide variety of human interests around the coasts from, roughly, Halifax to Connecticut but within the Moratorium Lands themselves is overwhelmingly dominated by two industries: fishing and shipping. Stantec made no mention of the latter whatsoever, unless one counts shipping movements directly associated with potential petroleum exploration and development.

Stantec's representation of the Georges Bank fisheries and their changes since 1999 was, at best, weak. In raw economic terms, good years have come and gone through the decade, but overall little has changed – as the Report admits (*Environmental Report* pp. 2.72–2.73). Closer inspection, however, would show that there have been fundamental shifts.

The scallop fishery, of course, remains the principal economic contributor to the Georges Bank fisheries, though Stantec offered no details of events in the past dozen years except that some of the scalloping companies have adopted factory-freezer vessels, reducing at-sea employment. That one point was evidently deemed important enough that it was repeated in the Executive Summary (*Environmental Report* p. E.2) but there was no mention of the major recruitment pulse (a repeated feature of scallops on Georges) that emerged early in the decade, no word of the quite unprecedented scallop recruitment south of Cape Cod, which increased U.S. landings and thus put downward pressure on prices, and no indication of the implications of exchange rates and fuel costs, all of which have been critical to the progress of the fishery since 1999.

If the scallop fishery has been overwhelmingly the most valuable on the Bank for some time, historically the principal employer was the fishery for groundfish, especially haddock. When the petroleum moratorium was first introduced in 1988, the Atlantic Canadian groundfish fisheries had already passed their prime. A partial recovery of the resources from the years of foreign overfishing had peaked around 1985, while prices and landed values fell after 1987. In 1988, however, those still seemed temporary trends and the fishery appeared to have a bright future – which goes far to explain the decision to institute a moratorium reserving Canada's richest fishing bank for the fisheries. However, the groundfish resources and the fisheries for them trended sharply downwards over the next few years and the fisheries off Nova Scotia were either closed or severely curtailed in 1993. By the time of moratorium extension in 1999, therefore, the richness of Georges groundfish was more of a hope for the future than an existing fact. That remained so until a massive year-class of haddock was spawned in 2003. Over the years since, those fish have grown to commercial size and have gone far towards creating a groundfish recovery

on the Bank. Some rebalancing of the resource is still needed, while rebuilding of other species such as cod is still awaited, but the promise and productivity of Georges Bank is once again an established fact. That change in circumstances is very likely the most important of the past decade on the Bank, ecologically, economically and as an issue for policymakers. Yet Stantec entirely missed the point – save for admitting to a doubling of landings and the advent of strong haddock year-classes (*Environmental Report* p. 2.52). Even that much did not find its way into the Executive Summary.

Fisheries, Offshore Petroleum & Economics

Stantec provided a mixture of information on the economics of both the fishing and petroleum industries in Nova Scotia, some of it in Section 2.3 of the *Environmental Report* (entitled "Socio-Economic Significance") and the rest in Section 5 ("Economics of Georges Bank")[15]. Between them, those sections present a scatter of summary statistics and some passing details of the fisheries but neither conclusions nor numbers from which readers might attempt to answer some of the questions at hand. The problem, of course, is that there is no credible way to estimate the value that petroleum activity on Georges might have, if the moratorium were lifted, nor to estimate the resulting losses to the fishing industry and other existing interests – except that the latter would certainly be more than zero but less than the total value with the moratorium in place. Without those numbers, it is difficult to discuss the economic merits of decisions about the future of Georges Bank.

The only possibly-useful comparison that I can see in the numbers offered in the *Environmental Report's* Section 5 is one between the fishing and offshore-petroleum industries in Nova Scotia as a whole in 2008 (Tables 5.1 & 5.12, pp. 5.2 & 5.15). That shows that fishing remains overwhelmingly the larger contributor to the Provincial economy, with more than three times the employment and more than three times the household income provided by offshore oil and gas. Only in contributions to GDP does the petroleum sector catch up and then only because, through a quirk in the definition of GDP, the figure includes the entire value of the gas flowing through the pipeline to New England, even though very little of that money ever comes near Nova Scotia (being paid by consumers in Massachusetts and elsewhere to oil companies in, probably, Texas). I have no reason to doubt that the GDP calculations were done correctly and follow the proper definition but they unreasonably magnify the economic impact on this Province – even without considering the loss of natural capital represented by the gas flowing away to market.

---

[15] The information provided was not fully reliable. Table 5.4 (*Environmental Report* p. 5.4), for example, claimed that annual landings from Georges have reached 75,000,000 tons, with groundfish landings alone reaching 17,500,000! The latter figure exceeds the historical peak landings of the world's largest fishery, for Peruvian anchoveta, and exceeds production of the world's largest groundfish fishery, that for Bering Sea pollock, by more than three times. It is possible that Table 5.4 presents landings in pounds, rather than the claimed tons.
It is unclear whether these landings data relate to Georges Bank, the Canadian portion of Georges or the Moratorium Lands – different, though overlapping, areas with different fishing activities within them.

Habitat Mapping

It remains to consider two topics by which Stantec appears to have set much store: habitat mapping and advances in the regulatory environment since 1999.

As oceans management faces the challenges of an ecosystems approach and moves beyond a simple focus on extractive industries, one of the urgent demands made on scientists is for meaningful maps of seabed habitats. Preparing those is proving to be a challenge somewhat beyond current capabilities, though tantalizingly close to achievement. Two different approaches are currently available for Georges Bank: On the U.S. side a "Swept Area Seabed Impact" ("SASI") model was developed in 2009 for application by the New England Fishery Management Council and is currently awaiting peer review, while Dr. Kostylev, of the Geological Survey of Canada and the Bedford Institute of Oceanography, has applied to Georges an approach which he has been evolving over the past decade, beginning with mapping of Browns Bank from 1996 onwards. Neither approach has yet been generally accepted by the scientific community and, at the time of writing, it seems unlikely that either will be – though each contains embedded ideas which will probably contribute to a future, effective solution.

Stantec chose to wade into this arena of on-going scientific inquiry, with a lengthy and sometimes lyrical account of the virtues of multibeam acoustic systems for mapping the seabed (*Environmental Report* pp. 2.1–2.25). The detailed bathymetry revealed by multibeam methods is indeed a huge advance for marine science of many kinds and one that has largely been realized since 1999, even though the basic survey methodology is older. What it cannot reveal, however, is the marine life on and in the seabed, which itself comprises a vital part of the habitat. The serious consequences of that deficiency were clear with the first application of what has become Dr. Kostylev's approach to habitat mapping (Kostylev *et al*. 2001) and their solution demands visual survey methods (e.g. towed camera bodies, laser line-scan techniques or simple drop cameras), which in turn generate so much data that they require automated identification (by computers) of the benthic animals recorded in the imagery. The necessary technology is under development but not yet ready for use.

Unfortunately, Stantec ignored the deficiencies in current capabilities and declared that further work by GSC will produce information that "will serve to protect sensitive habitats and minimize resource conflicts" (*Environmental Report* p. 2.25). So important did Stantec consider this development that it was one of the very few substantive topics featured in the Executive Summary, where it was declared "a substantial advancement in the identification and protection of sensitive habitats" (*Environmental Report* p. E.3).

Those are tasks far beyond the capabilities of existing mapping technologies – as is clearly demonstrated by Stantec's own Figure 2.17 (*Environmental Report* p. 2.24)[16].

That figure shows, by colour shading, the results of the current application to Georges Bank of Dr. Kostylev's approach. His calculations produce four mapped habitat types, arranged in vaguely-concentric fashion around the shoal water of Georges – though data for the mapping currently only exist for the Canadian portion of the Bank. Stantec's Figure 2.17 also shows, as black dots, the location of scalloping effort. While captains make some exploratory tows, the bulk of that effort will have gone where scallops are relatively abundant. Hence, the dots indicate not only the distribution of scalloping but also that of scallops. On Georges, the shellfish are themselves a key component of the benthic ecosystem, while their presence is a sure indicator of habitat conditions suited to scallop survival and growth. In short, the black dots on Figure 2.17 indicate the distribution of one particular habitat type. It is clear that this scallop habitat is not randomly distributed across Georges but shows a specific pattern, with a band along the Northern Edge and a series of north-south bars across the Northeast Peak. Those bars, which likely lie on patches of lag gravels, conspicuously cut across the coloured bands derived from Dr. Kostylev's approach. In other words: The approach to mapping habitat by which Stantec have set so much store entirely failed to identify the habitat type utilized by the benthic species of greatest socio-economic importance on Georges and instead directs the decision-maker's eye towards quite other areas. It is, in short, a misleading approach which entirely fails to meet Stantec's optimistic claims for its capabilities.

Seabed habitat mapping most certainly is advancing quickly, by the glacial standards of scientific research, and has moved forward significantly since 1999 but the state of the art in 2010 is still not sufficient to provide reliable maps of Georges Bank suited to spatial planning decisions by marine managers. Stantec's conclusion to the contrary was disproved even by the evidence assembled in its support.

<u>Regulatory Environment</u>

One of the few fields in which the past dozen years have seen some progress towards protection of the marine environment in those areas where the offshore petroleum industry operates is the arena of legal, regulatory, administrative and voluntary controls – progress which earned the issue some space in the *Environmental Report's* Executive Summary (p. E.3). Elsewhere, Stantec's report claimed a dozen advances (*Environmental Report* Table 3.1, pp. 3.3–3.4). Within that number, however, the Accord Acts have not been substantially changed since 1999, Bill C-32 (which was to substantially revise the

[16] Stantec credited their Figure 2.17 to "Kostylev 2009", a designation which does not match any entry in their list of cited sources. It is not clear whether the figure was or was not drawn from a peer-reviewed, published source.

Fisheries Act) died on the order paper in September 2008[17], while the Oceans Act was in force before 1999. Thus, the updates since the Panel Review actually amount to:

a: 1999 revisions to the Canadian Environmental Protection Act
b: 2001 revisions to the Canadian Environmental Assessment Act
c: Species at Risk Act of 2002
d: Offshore Waste Treatment Guidelines of 2002
e: Compensation Guidelines of 2002
f: Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment of 2007
g: Canada Oil and Gas Drilling and Production Regulations of 2009, with various associated guidelines being in draft form
h: Offshore Chemical Selection Guidelines of 2009

Each of those eight will doubtless assist in moderating the adverse effects that the offshore petroleum industry imposes on ocean ecosystems and other ocean users. Whether the entire suite, even in combination, will make a material difference to those effects is, however, another question. CEPA and the Waste Treatment Guidelines, for example, do not prevent the discharge of WBM or produced water. The revisions to CEAA belatedly applied the environmental assessment process to CNSOPB decision-making but still allow exploratory drilling with no more than a cursory screening assessment. The Compensation Guidelines still do not provide for other ocean users to be compensated for losses resulting from environmental harm caused by offshore-petroleum activities. As already discussed, the 2007 "Statement" of seismic-survey practices does little to address the key concerns over potential surveys on Georges Bank. The 2009 Regulations and Guidelines are too recent for their effects to be known but, since their aim is to introduce regulatory flexibility through a goal-oriented approach (itself a worthy aim), reductions in environmental harm are likely to prove only incidental benefits. That leaves only SARA to prevent activities that would harm species at risk – a restricted focus and a great burden to place on the machinery of an Act never intended as a foundation for oceans management.

Meanwhile, the regulatory regime as it existed before these minor upgrades is increasingly seen as inadequate, not least because the Offshore Petroleum Boards, CNSOPB and C-NLOPB, have the conflicting roles of facilitating exploration for and development of resources while also ensuring that oil and gas activities offshore are conducted with no more risk to the environment or to human health and safety than is appropriate. Experience suggests that no one agency can readily balance such opposed tasks. Stantec made a point of claiming that the Review Panel appeared to dismiss the idea of separating safety and environmental protection from the regulatory authority of the Board (Environmental Report p. 3.1) but that stance is unclear in the Panel's own

[17] Curiously, Stantec claimed that the "Fisheries Act 2007" has not yet received Royal Assent (*Environmental Report* p. 3.11). In reality, Bill C-32 never went beyond Second Reading.

wording (Panel Report p. 40). What is certain is that one of the first responses of the U.S. Secretary of the Interior to the Deepwater Horizon disaster (on 19 May 2010) was to split what were seen as three conflicting responsibilities of the Minerals Management Service among new and independent agencies: the Bureau of Ocean Energy Management, the Bureau of Safety and Environmental Enforcement and the Office of Natural Resources Revenue. A very similar separation was recently recommended for the C-NLOPB by the Wells Commission, following an inquiry into a fatal helicopter crash, and that recommendation has been accepted by the Government of Newfoundland and Labrador[18].

Stantec further claimed that CNSOPB's approach to consultation and liaison was generally seen as acceptable in 1999 (*Environmental Report* p. 3.2). It is unlikely that the Nova Scotian fishing industry would endorse that position today, the failure of trust being another important trend of the past dozen years which Stantec missed.

More generally, while these comments are sharply critical of Stantec's two reports prepared for the OEER, I see no reason to suppose that their quality is any lower than the material that the same company or its principal competitors would generate for private-sector clients, including those in the offshore-petroleum industry. Until there is material advance in the analyses that underpin environmental assessments, the established operating procedures of CNSOPB and CEAA cannot be relied upon to provide adequate protection to special areas. Reserving such areas from petroleum activity is not the Board's job. Special areas require special management measures, such as a specific moratorium on harmful activities.

Summaries

Few affected stakeholders will ever read Stantec's reports in their entirety and most of those who will have a hand in making decisions about the moratorium will not have time to get very far beyond the summaries – which makes those in some ways the most important parts of the reports, even though they should be no more than derivatives of the main text. That Stantec's Executive Summary of its *Environmental Report* failed to adequately capture the key messages in its text has been repeatedly noted above. The *Report* did, however, offer a second and rather different summary in its Section 6[19].

As noted above, that Section is compromised by a stated reliance on the "professional opinion of Study Team authors" (*Environmental Report* p. 6.1) when no evidence has been advanced indicating that the "Key" members of the Team had any professional competence in relevant fields. It also repeated the claim that EEM has failed to detect population-level effects of offshore-petroleum activities off Atlantic Canada

[18] Even these are late examples. Similar separations of responsibilities are said to already be in place in other jurisdictions, including both Australia and the United Kingdom.

[19] A third level of summary is available on the OEER website, entitled *OEER Georges Bank Review: Summary Document*. That offers an even greater degree of over-simplification and selection than is seen in the summaries provided by Stantec. It does not merit review here.

(*Environmental Report* p. 6.6), which interpretation has been dismissed above. Otherwise, almost all that Section 6 offered was a four-page tabular summary (Table 6.1, pp. 6.2–6.5).

Unfortunately, that Table continued the misrepresentation seen in the Executive Summary. Under "Physical Environment" , for example, it declared that the 1999 *Review Report* found that the estimated oil and gas potential of Georges exceeded that of existing Atlantic Canadian projects. That was simply false. All that the Review Panel did was to quote the estimates from Proctor *et al.* (1984) and they chose to use the "high confidence" estimates from that source, which suggest one tenth as much oil on Georges as at Hibernia and less than half as much gas as in the fields developed by Sable Offshore Energy Inc. (*Panel Report*, pp. 16–17, 57)[20]. In the same cell of Table 6.1, Stantec claimed that the Panel recommending mapping of Georges. If so, I cannot find it mentioned in the *Panel Report*. Under "Regulation of Development", Stantec claimed that the Panel had said that the existing regulatory regime is quite comprehensive without "imposing total bans". I can find no such comment in the *Review Report*.

In the "Update" column of Table 6.1, Stantec placed mistaken reliance on habitat mapping; noted improvements in interpretation of seismic data (while failing to explain their significance to environmental questions); listed a number of points under "Ecological Significance", most of which do not alter the picture as seen in 1999, though a few make Georges Bank appear even more significant; gave no information on changes in the fisheries at all; listed a series of regulatory upgrades without showing why they materially change the degree of protection that the CNSOPB accords to marine ecosystems; misrepresented current scientific understanding of the effects of scientific surveys; placed reliance on the *Statement of Canadian Practice with Respect to Mitigation of Seismic Sound* which that limited document cannot bear; noted improvements in the options chosen for drill-mud use off Atlantic Canada, without offering any advance in practices with WBMs (which are both the expected principal muds that would be used on Georges and also those which most threaten the benthos); invoked fallacious conclusions from EEM; presented assorted points concerning global warming of questionable relevance to the moratorium; repeated the false claim that spillages by the offshore petroleum industry are decreasing, while quoting erroneous volumes spilt; complemented that with an assorted series of points, including a troubling observation of a "renewed interest" in chemical dispersants; noted the improvements in tanker safety; provided platitudes about seabed mapping and planning to avoid problems with loss of fishing access resulting from seismic, while extending the notion of "coexistence" of the fishing and petroleum industries to experiences on the Grand Banks

[20] It was Stantec, in its *Technologies Report* which chose to cite Proctor *et al.'s* (1984) "average expectation" estimates of 1.1 billion bbls of oil and 5.3 tcf of gas, without expressing any caveats (*Technologies Report* p. 1.4). Procter *et al.* (1984) actually estimated between 0.06 and 2.3 billion bbls plus between 1.3 and 11 tcf on Georges – estimates so uncertain as to be valueless as a guide for decision-makers.

and the Scotian Shelf; returned to misrepresentations of conclusions from EEM and of knowledge of the effects of seismic; offered points of questionable relevance concerning submarine pipelines; and then finished by again returning to the invalid conclusions from EEM. That mass of words may have been intended to leave an impression of extensive advances since 1999 – sufficient to justify reconsideration of the Review Panel's decision to extend the moratorium. A more careful reader might, however, share the current writer's conclusion that, if Stantec could find no greater advances than were listed in Table 6.1, then there are no grounds to re-open the decision of 1999. It is not that there have been no advances but rather that the real developments addressing the Panel's concerns have been minor. The regulatory regime does seem to have progressed but not far. Tanker safety has undoubtedly improved, while toxic oil-based drill muds have been replaced by low-toxicity "synthetic" alternatives, but neither tanker accidents nor the local toxic effects of oil on drill cuttings were central to the Review Panel's reasons for extending the moratorium in 1999.

That being so, one might have hoped that Stantec would have noted, in the "Residual Issues" column of Table 6.1, that most of the concerns of 1999 remain equally valid today. Instead, that column was largely used for research-related points, following Stantec's definition of "residual issues" as "remaining data gaps" (*Environmental Report* p. 4.1), though some of the points made were mere platitudes, re-stating points well understood long before 1999. Some of the suggested study topics would indeed merit scientific attention but Stantec fell far short of providing a comprehensive or balanced list of research requirements. That was hardly unexpected, given that the Study Team was so selective of issues, so ignorant of current scientific knowledge and so lacking in research expertise. The final column of Table 6.1, labelled "Research Recommendations" was no better handled. Recommending research needs is a task better reserved for experienced, senior scientists specializing in the topics in question – an expertise that Stantec seems to have been unable to provide.

Section 6 of the *Environmental Report* ended with an overall conclusion that the issues identified in 1999 "could be reasonably mitigated in the event that oil and gas activities are permitted to occur on Georges Bank" – wording that was quoted verbatim in the Executive Summary (*Environmental Report* pp. E.4, 6.6). Given the very limited advances in the last decade, that conclusion was absurd. Moreover, it was not supported by any logical analysis founded on Stantec's claims of the advances achieved. Rather, it was pulled out of thin air and justified only as "the professional opinion of the Study Team" (*Environmental Report* pp. E.4, 6.6) – a Study Team which has no known professional competence relative to the suite of issues involved in the stated conclusion.

Commentary Conclusion

Stantec's *Environmental Report* prepared for OEER was not entirely lacking in merit. Unfortunately, however, only those who well understand the topics addressed and the extent of current scientific knowledge of them can hope to distinguish

between the truths, half-truths and falsehoods it presented – and that is the one audience which never needed the information offered in the *Environmental Report*.

A Preliminary Review of Existing Technologies and their Mitigative Potential in Offshore Petroleum Developments

In contrast to the *Environmental Report*, the main text of Stantec's *Technologies Report* was quite well prepared, though its authors could not entirely escape the limitations inherent to an updating of the 1999 *Review Report*. They did out-grow the constraints of their own title, however, by looking at emerging technologies as well as those existing, while putting more stress on practices, guidelines and regulations than on technologies at any stage of development. What is most noticeable of this *Technologies Report* (as of its environmental twin) is, however, the dislocation between its main text and the conclusions presented in both its Executive Summary and its "Summary of Residual Issues and Research Recommendations" (*Technologies Report* Section 3) – the latter's title being simply a misnomer.

Seismic Surveys

Stantec devoted curiously-large amounts of space in the *Technologies Report* to issues which did not come up during the 1999 Panel Review, such as "Air Emissions" (*sic* – meaning atmospheric emissions) and even produced water, but the central concern a decade ago, the effects of seismic surveys, was given short shrift. Following a rather muddled paraphrasing of the *Review Report* (which indicates no apparent effort to consider the arguments raised a dozen years ago by presenters nor their supporting documentation), Stantec claimed that modern 3D survey methods eliminate the need for repetitive mapping and allow "a one-time pass over the seabed area" (*Technologies Report* p. 2.4) but then noted that recently-adopted "4D seismic" involves "repeating 3D at regular intervals" (*Technologies Report* p. 2.6). Considering that recent developments in 3D seismic involve multiple-vessel surveys, with each ship simultaneously towing an air-gun array while steaming on parallel tracks (*Technologies Report* p. 2.7), far from the past dozen years having seen mitigation of the negative effects, one might reasonably suppose that they have become dramatically more severe. Stantec did not conclude as much but did note that access and crowding remain issues.

Following an overview of the emerging technologies for petroleum exploration ahead of drilling which might render seismic surveys unnecessary, Stantec concluded that "it is uncertain if these systems could ever be used to conduct stand-alone exploration geophysical surveys" and "Until there is a viable alternative, seismic survey technology will continue to rely on airguns" (*Technologies Report*, p. 2.9). Those seem sensible appreciations. What is certain is that there is no existing and established technology that could allow petroleum exploration to proceed on Georges Bank without the prelude of a seismic survey. One might, therefore, suppose that the *Technologies Report* would have concluded that the concerns raised by the Review Panel in 1999 all remain as residual

issues for the foreseeable future. Curiously, however, Stantec did not do so. Despite presenting a "Technological Update" relative to seismic surveys which acknowledged no relevant progress since 1999 (*Technologies Report*, Tables E1 & 3.1, pp. E.3 & 3.3), summary of the "Residual Issue" was confined to a repeat of one of the lesser aspects of the original concern, a caveat to some of the (already ineffective) technological advances and a bullet point which belonged among those "Updates". Three useful recommendations for research (which lacked any supporting argument elsewhere in the document) were provided but the primary need, careful and detailed studies of the effects of full-scale seismic surveys, was not mentioned at all. Nowhere did the *Technologies Report* admit that the concerns raised a dozen years ago remain as valid today as the Panel found them to be then.

Those concerns were not matters of divergent opinions, lacking the support of specific studies, as Stantec have suggested (*Technologies Report* p. 2.3). Neither were they focused on catch reductions alone (cf. *Technologies Report* p. 2.3) and it was most certainly false to claim that the effects of seismic on a range of marine biota "are expected to be low with no serious or long term harm at the population level" (*Technologies Report* p. 2.9). That declaration displayed only its authors' ignorance of either the relevant literature, marine population biology or both. It would do so even if only the classes of impacts considered in 1999 were admitted for discussion. In *Environmental Report*, however, Stantec introduced the non-lethal, physical effects of seismic on adult fish (as distinct from the immediately-lethal effects on fish larvae), notably the tearing of nerve connections in vital sensory organs. Research on that topic has yet to proceed far but it adds an additional layer of uncertainty to the previously-known concerns over the (far more certain) behavioural impacts of seismic.

Drill Muds & Cuttings

The second major class of concerns about potential petroleum activities on Georges Bank that was raised in 1999 related to the discharge of drilling wastes. Stantec provided interesting information on emerging technologies which may one day allow the drilling industry to achieve newly-tightened limits on the discharge of coatings of synthetic oil (from drill muds) on drill cuttings – though it also revealed that a recent study found that those limits are not currently being met (*Technologies Report* p. 2.17). Unfortunately for Stantec's argument, however, the concerns in 1999 primarily related to the bulk discharge of WBMs and not to oil coatings at all – as has been explained above in relation to the *Environmental Report*. Reductions in discharges of synthetic oils, while they are to be welcomed, would not mitigate existing concerns because nobody has expected any form of oil-based muds to be used in much quantity on Georges (cf. *Technologies Report* p. 2.18).

Stantec made much of the potential for directional drilling as a means for mitigating these discharges. That approach has indeed been used to access petroleum under specially-valued seabed habitats which are deemed to merit protection from the local presence of a drill rig – such as the coral reefs of the Flower Gardens Marine Sanctuary in the Gulf of

Mexico. That Sanctuary is, however, only 7 km across at its widest point, making external access to hydrocarbons under its heart well within the capabilities of existing technology, which can reach sideways distances a few times greater than the depths of the wells (*Technologies Report* p. 2.14). The Canadian portion of Georges Bank, in contrast, is ten times wider than the Flower Gardens, while extensive swaths of it are important to fisheries production. Thus, the potential to use directional drilling to mitigate impacts on Georges is limited. Considering that such drilling usually increases the need for oil-based drill muds and increases the volume of cuttings, while Stantec's conception of the approach would have the discharges from drilling multiple wells concentrated at one location (increasing the zone with harmful concentrations), it does not seem to be a very attractive alternative for the current Moratorium Lands.

Thus, all that the *Technologies Report* had to offer by way of mitigation of the concerns over drilling wastes that were noted in 1999 was that DFO's capability for modelling the dispersion of drilling wastes has improved in the last dozen years, while EEM has been used to assess predictions of environmental effects of offshore petroleum projects (*Technologies Report* p. 2.18). The latter claim has already been discounted in the above review of the *Environmental Report*. The modelling has indeed been refined, though it may be noted that the "BBLT" model in question was developed for the support of the 1999 review and changes in it have hardly been the "significant advancements" that Stantec has claimed. Besides, an ability to better predict the degree of an effect does nothing to mitigate that effect unless decision-makers use the enhanced knowledge to prevent the modelled impact – something best achieved in the present case by maintaining the moratorium.

When it came to summarise this topic (*Technologies Report*, Tables E1 & 3.1, pp. E.4 & 3.4), however, Stantec misrepresented the concerns of 1999, stating that synthetic oil-based muds were not then widely used when the issue was one of bulk discharge of WBM, that the potential for effects on scallops 40 km from a discharge point was based on "Laboratory experiments" when that result came from the BBLT model, while the dispersion of drilling muds was said to have been "not fully understood" – a quotation from a DFO document which used those words to preface a warning that effects could be worse than the BBLT model suggested. Stantec's proffered "Technological Update" noted the demise of conventional oil-based muds, which were already all but absent from the 1999 expectations of the future of Georges, mentioned the revised standards for oil on discharged cuttings (which standards cannot yet be achieved and are not relevant to the bulk discharge of WBMs anyway), remarked on the forthcoming technologies for treatment of cuttings, which are again not relevant to WBM drilling and which are in any case not ready for application (*Technologies Report* p. 2.18), noted the availability of better risk assessment models and the possibilities of reinjection and directional drilling – neither of which was unknown or indeed unconsidered in 1999. Having thus failed to suggest any new technologies which might significantly mitigate the anticipated effects of drilling discharges, one might have hoped that Stantec would have acknowledged some residual issues. Instead, the relevant column of Tables E1 and 3.1 of the

Technologies Report only offered two caveats to the adjacent "Technological Update". The sole proposed research was an investigation of "zero harmful discharge practices" – a misnomer, considering that the sole cited example of an attempt to apply such an approach ended up discharging the WBM that is known to be harmful to scallops and other filter feeders. Considering that the Review Panel's comment, in 1999, was "For drilling wastes discharged from a rig on or near Georges, the probability that significant, harmful effects would occur cannot be discounted" (*Panel Report* p. 35), the absence of any additional effective mitigation measures developed in the past dozen years confirms that critical obstacles to allowing drilling in the Moratorium Lands remain.

Spills & Blowouts

The third major class of concerns raised in 1999 related to accidents, particularly spills and blowouts. Stantec's arguments on that issue amounted to nothing more than that regulations have been tightened and the risks of accidents reduced. That the rules have been enhanced is undoubtedly true – though the only example specified by Stantec from the past dozen years was a 2008 CAPP "Standard Practice for the Training and Qualification of Personnel" (*Technologies Report* p. 2.37). Whether those enhancements will have any material effect on the incidence or severity of offshore accidents is unclear, not least because the realized performance depends not on regulations alone but also on their application and on opportunities for cost-cutting in unregulated areas.

As outlined in the above review of the *Environmental Report*, Stantec claimed a reduction in average annual spillage from petroleum industries over recent decades (*Technologies Report* p. 2.36, cf. p. 2.40) that has simply not happened – or at least is not demonstrated by the available data. As with its twin, the *Technologies Report* included a discussion of capabilities for cleaning up spills, though Stantec could again point to no substantial changes since 1999, while recent experience in the Gulf of Mexico has confirmed what was already known – the available technology is not effective offshore. In that regard, it may be noted that Boudreau *et al.*'s (1998) estimation that surface slicks would disappear within a week or two due to high rates of vertical mixing (which was quoted in the *Technologies Report*: p. 2.40) was merely a re-statement of what was known to the Panel in 1999. Moreover, it was and is a reminder that oil spilt on Georges Bank would not just go away but would disappear from sight by being mixed downwards into the water column, where it would affect fish and shellfish.

In summarizing the issues concerning accidents (*Technologies Report*, Tables E1 & 3.1, pp. E.8 & 3.8), Stantec's "Technological Update" again referred to the supposed enhancement of training to avoid accidents, cited Etkin's (2009) compilation of statistics (supplemented with an appeal to unspecified CNSOPB and C-NLOPB sources and a report on tanker spills), presented a farcical comparison of quantities of oil spilt with the magnitude of natural seeps, and ended with a claim (unsupported by anything in the text of the *Report*) that fate and effect models are being continuously improved – as though development of such models could do anything to reduce the frequency or severity of accidents. There was no indication among those points of any reduction in risk, once

Etkin's (2009) data have been re-analyzed – save for the reduction in tanker accidents, which were not considered in 1999 anyway.

Having failed to suggest any evidence that the risk of spills has been reduced in the past dozen years, Stantec should once again have admitted that the "Residual Issue" is identical to the concerns dating from 1999. Save for an acknowledgement that the remote risk of a spill (which is only remote if discussion is limited to very large spills) "will always remain", no such admission appears in the *Technologies Report*. Instead, Stantec invoked supposed learning from other spill events to inform decision-making (which, if it had any of the relevance to Georges that it so conspicuously lacks, would have belonged in the column on "Technological Updates").

Other Concerns

As noted above, the *Technologies Report* devoted space to updating knowledge of issues that were not in the remit of the 1999 Panel Review, since they concern production scenarios whereas the process a dozen years ago only looked at petroleum exploration. The first of those issues was produced water, for which Stantec could cite multiple new treatment approaches (*Technologies Report* pp. 2.20–2.24). Those are doubtless useful advances and no doubt the best-practicable technology should be employed if the moratorium were lifted and if oil or gas were ever produced on Georges Bank. However, the new technology would be devoted to further reducing an already-insignificant issue: As Stantec said: the "effects of produced water on individual development sites in the open ocean are likely to be minor" (*Technologies Report* p. 2.25). Elsewhere in the world, discharges of produced water are problematic but, given the degree of water movement on Georges and the location of the Bank on the edge of the open Atlantic, the amount of produced water, once cleaned up in accord with the standards even of 1999, that could come from a single production project would have minimal environmental effects.

Even with such a non-issue, however, Stantec was unable to provide a balanced summary (*Technological Report*, Tables E1 & 3.1, pp. E.5 & 3.5). Instead, the "Technology Updates" included re-injection methods, which were not new even in 1999, and fate-and-transport models which do nothing to reduce the effects of discharged contaminants. Stantec's "Residual Issues" were, once again, nothing of the kind.

Atmospheric emissions were treated similarly. The summary offered (*Technologies Report*, Tables E1 & 3.1, pp. E.6 & 3.6) picked up an aside comment in the *Panel Report* concerning the use of natural gas as a transition fuel, which was not an expression of concern so much as a dismissal of the relevance to the 1999 Panel Review of concerns about greenhouse-gas production. Meanwhile, the only new technology offered by Stantec was a requirement to report both greenhouse gas emissions and the release of volatile organics from offshore installations.

For pipelines and tankers (other issues which fell outside the remit of the 1999 review), Stantec noted the decline in tanker spills over time but could claim no advance in pipeline technology or practices, save for modern abilities to map potential routes. Since past experience off Nova Scotia has revealed little inclination for project planners to use the available tools to minimize the environmental impacts of their pipelines, the development of improved mapping does not carry much promise of reduced harm[21].

While thus attempting to document updated technology in areas which were not considered by the 1999 Panel, Stantec chose not to address the loss of access and crowding of other ocean users that would result from drill rigs and other offshore platforms –issues that were very much considered in 1999– though they did consider those aspects of seismic surveys.

The *Technologies Report* ended with the grossly-misleading statements about EEM that have been considered above with respect to the *Environmental Report*. Otherwise, Stantec admitted that "some" of the risks identified in 1999 remain, when almost all of them do, but sought to evade the inescapable conclusion that the Review Panel's recommendation to retain the moratorium remains valid today by declaring that "it is not realistic to assume that all risks can be mitigated by technological advances alone" (*Technologies Report* p. 3.9). It is not but no such assumption was made when the moratorium was introduced, nor when it was subsequently extended.

For its Executive Summary, Stantec chose a more definite conclusion, declaring that the issues identified by the 1999 review "could be reasonably mitigated due to advances in scientific knowledge, mitigation and regulatory requirements in addition to technological advances" (*Technologies Report* p. E.2 & 3.9). If so, the Study Team entirely and singularly failed to explain how that might be achieved. Stantec did not even point to means by which the mitigation might be attempted.

Commentary Conclusion

The *Technologies Report* provided some interesting information on technological advances by the offshore petroleum industry through the years since 1999, including advances that are not yet ready for application. It did not, however, offer anything that amounts to a justification for reversing the 1999 recommendation of the Review Panel – the recommendation to retain the moratorium on petroleum activities on and around Georges Bank.

[21] Stantec's absurd statement that bottom fishing "may take place in water depths up to approximately 80 m" (*Technologies Report* p. 2.34) would best be passed over without comment.

References

Barlow, M.J. & P.F. Kingston (2001) Observations on the effects of barite on the gill tissues of the suspension feeder *Cerastoderma edule* (Linné) and the deposit feeder *Macoma balthica* (Linné). *Mar.Poll.Bull.* 42(1): 71-76.

Engås, A., S. Løkkeborg, E. Ona & A.V. Soldal (1993a) *Effekter av seismisk skyting på fangst og fansttilgjengelighet av torsk og hyse. Fisken og Havet* 1993(3): 111p. [In Norwegian]

Engås, A., S. Løkkeborg, E. Ona & A.V. Soldal (1993b) Effects of seismic shooting on catch and catch-availability of cod and haddock. *Fisken og Havet* 1993(9): 117p.

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*). *Can.J.Fish.Aquat.Sci.* 53: 2238-2249.

Etkin, D.S. (2009) Analysis of U.S. oil spillage. *American Petroleum Institute Publication* 356: vi+71p.

Hurley, G. & J. Ellis (2004) Environmental Effects of Exploratory Drilling Offshore Canada: Environmental Effects Monitoring data and literature review – Final Report. *Report prepared for the Canadian Environmental Assessment Agency, Regulatory Advisory Committee*: 115p.

International Association of Oil & Gas Producers (IAOGP) (2010) Blowout Frequencies. *OGP Risk Assessment Directory, Report No.* 434 – 2.

Kenchington T.J. & R.G. Halliday (1994). A survey of fishing practices in the Scotia-Fundy Region groundfish longline fisheries. *Can.MS Rep.Fish.Aquat.Sci.* 2225: 642 p.

Kostylev, V.E., B.J. Todd, G.B.J. Fader, R.C. Courtney, G.D.M. Cameron & R.A. Pickrill (2001) Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. *Mar.Ecol.Prog.Ser.* 219: 121-137.

Løkkeborg, S., E. Ona, A. Vold, H. Pena, A. Salthaug, B. Totland, J.T. Øvredal, J. Dalen & N.O. Handegard (2010) *Effekter av seismiske undersøkelser på fiskefordeling og fangstrater for garn og line i Vesterålen sommeren 2009. Fisken og Havet* 2010(2): 76p. [In Norwegian with English summary]

McCauley, R.D., J. Fawtrell & A.N. Popper (2003) High intensity anthropogenic sound damages fish ears. *J.Acoust.Soc.Am.* 113: 638-642.

Proctor, R.M., G.C. Taylor & J.A. Wade (1984) Oil and natural gas resources of Canada 1983. *GSC Paper* 83-31.

Richardson, W.J. (2002) Marine mammals *versus* seismic and other acoustic surveys: Introduction to the noise issues. *Polarforschung* 72(2/3): 63-67.

Skalle, P. & A.L. Podio (1998) Trends extracted from 1,200 Gulf Coast blowouts during 1960º1996. *World Oil* June 1998: 67-72.

Thorne, R.E. & G.L. Thomas (2008) Herring and the "Exxon Valdez" oil spill: an investigation into historical data conflicts. *ICES J. Mar. Sci.* 65: 44-50.