Environmental Assessment
East Canada CSEM Survey, 2014–2018
Addendum

Prepared by

LGL LIMITED
environmental research associates

Prepared for

emgs

2 July 2014
Project No. SA1248

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GENERAL COMMENTS

Environment Canada – CWS

Please note that EC's previous comments on the scoping document and project description (submitted to you on 17 January 2014) are still applicable to the project as described in the EA report.

> ***Response:*** EMGS agrees that previous comments are still applicable.

The proponent should be reminded that results from the onboard seabird observation program should be sent to EC-CWS on an annual basis.

> ***Response:*** EMGS commits to sending results from the onboard seabird observation program to EC-CWS on an annual basis.

Fish, Food and Allied Workers (FFAW)

Original Comment: Overall the report provides a perspective of the commercial fishery of the inshore fleet. However, as half of the Study Area and the majority of the 2014 proposal survey block is outside Canadian jurisdiction, harvesting data from NAFO would more accurately portray commercial fishing (harvesting) locations outside of the 200 mile limit, particularly for shrimp, turbot, redfish and cod.

The FFAW were engaged in a consultation with EMGS in January 2014 regarding their project however they have heard nothing from EMGS since that time. Pre-planning is important to minimize potential conflicts and any negative impacts on fishing activity, particularly as it appears that activity in the offshore in 2014 will be quite busy.

> *EMGS Response:* As stated in the first paragraph in Section 4.3.1.1 Data Sets, p.50, NAFO harvesting data in areas outside the Canadian 200 nautical mile limit is derived from STATLANT data, which is not geo-referenced but rather geographically resolved at the NAFO Division level only. Therefore, it is not possible to create a map portraying specific commercial harvesting locations outside the 200 nautical mile limit. Section 4.3.2 Regional NAFO Fisheries, page 51-52, however, provides total catch weight percentages for some of the dominant species captured in NAFO Divisions outside of the Canadian EEZ.
>
> It is agreed that pre-planning is important for minimizing potential conflicts and negative impacts on offshore fishing activities. Section 6.3 of the EA describes mitigation and follow-up strategies related to the fisheries. Pre-planning at an early stage was not possible as the land tenure system that allows identification of the final survey locations was not finalized before May 2014.

FFAW Response: As the proponent suggests that the NAFO data cannot be mapped due to not being geo-referenced, they need to be mindful that there will likely be harvesting activity outside the 200 nautical mile limit. This will include both large Canadian and foreign vessels.

In the context of the comment on lack of communication, it is now June and there has not been any further communication from the proponent directly other than the meeting in January. The problem with the shortage of communication is that it leaves stakeholders wondering if proposed projects are still progressing. Further, communication and pre-planning is the manner to minimize potential conflicts and any negative impacts between industries and projects.

> *EMGS Response:* EMGS is aware of the likelihood of harvesting activity outside of the 200 nautical mile limit by large Canadian and foreign fishing vessels.
>
> Regarding the issue of lack of communication, on June 27, 2014, EMGS sent an email to all groups initially consulted in January that updates survey details, including the delineation of the 2014 CSEM survey area.

SPECIFIC COMMENTS

Canada – Newfoundland and Labrador Offshore Petroleum Board

Section 1.0 Introduction, second paragraph, last sentence, pg 1 – This sentence is awkward and should be rewritten to clearly express the idea trying to be communicated.

> ***Response:*** Revise the last sentence in the second paragraph of Section 1.0, p.1, as follows:
>
> "The resulting CSEM data enable oil companies to lower risk prior to drilling and ultimately increase exploration success by reducing the amount of dry wells as well as reducing the overall environmental footprint of drilling programs."

Section 1.3 EMGS Environmental Policy, second bullet, pg 5 – Minor point on consistency, but Environmental Policy should either be capitalized or not as it is in the following (third) bullet.

> ***Response:*** Capitalize "environmental policy" in the second bullet, p.5, to maintain consistency with the remainder of Section 1.3.

Section 2.2 Project Overview, 3rd para, 2nd & 4th lines, pg 7 – "*if required*". There are commitments made throughout the report to marine mammal monitoring. The EA should be consistent. It is expected that a marine mammal and seabird observer, as per the "*Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012)" will be on board the vessel.

> ***Response:*** Agreed. Marine mammal and seabird observers will be on board the vessel.

Section 2.10 CSEM Receiver Packages, first sentence, pg 9 – Electromagnetic is spelled incorrectly.

> ***Response:*** Edit "electromagetic" to "electromagnetic" in the first sentence, Section 2.10, p.9.

Section 3.1 Bathymetry and Geology, second paragraph, pg 12 – "*The* Flemish Pass is a saddle-shaped,.."

> ***Response:*** Edit "Flemish Pass is a saddle-shaped, mid-slope basin…" to "The Flemish Pass is a saddle-shaped, mid-slope basin…" in the second paragraph, Section 3.1, p.12.

Section 4.2.4.1 Macroinvertebrates and Fishes Primarily targeted in Commercial Fisheries, subsection Northern Shrimp, last paragraph, pg 35 – "...isobaths on the northeastern slope of *the* Jeanne d'Arc Basin in..."

> ***Response:*** Edit "…isobaths on the northeastern slope of Jeanne d'Arc Basin…" to "…isobaths on the northeastern slope of the Jeanne d'Arc Basin…" in the last paragraph in Section 4.2.4.1, *Northern Shrimp*, p.35.

Section 4.3.1.1 Data Sets, last sentence, pg 50 – While the reviewer understands what is meant by "...3Kbcfgk, 3Ldehirt, 3Mabc, and 3Nabcd..." it may not be obvious to others. A suggested clarification is ""...3K (sub areas b/c/f/g/k), 3L (sub areas d/e/h/i/r/t), 3M (sub areas a/b/c), and 3N (sub areas a/b/c/d)..."

> ***Response:*** The above nomenclature is a common method used to list multiple NAFO Unit Areas within multiple NAFO Divisions. If required, two alternative methods to expand this list are:
>
> "3Kb, 3Kc, 3Kf, 3Kg, 3Kk, 3Ld, 3Le, 3Lh, 3Li, 3Lr, 3Lt, 3Ma, 3Mb, 3Mc, 3Na, 3Nb, 3Nc, and 3Nd."
>
> OR
>
> "3K (subareas b/c/f/g/k), 3L (d/e/h/i/r/t), 3M (a/b/c), and 3N (a/b/c/d)."

Section 5.6 Effects of Environment on Project, second paragraph, pg 140 – It should read, "Similar percentages for exceedances of significant wave height..."

> ***Response:*** Edit "Similar percentages for exceedance of significant wave height…" to "Similar percentages for exceedances of significant wave height…" in the second paragraph, Section 5.6, p.140.

Section 5.7 Effects of the Project on the Environment, pg 141 – The physical effects of the anchors on applicable VECs (e.g. corals) should be included in the assessment. More detail should be provided on the overall footprint of up to 200 anchors on the seabed. The "anchors" should be identified as a separate project activity under seabed disturbance in Tables 5.3 and 7.1 the assessment of effects on VEC's.

> ***Response:*** The overall footprint of all 200 anchors is 149 m^2 (0.000149 km^2) which represents an extremely small percentage of the Project Area ($5.3x10^{-10}$ %). Any effect on benthic communities is likewise infinitesimally small. In terms of effects on corals and sponges, there is some potential for smothering from the anchors. However, risk of smothering is reduced by the small footprint of the anchors and the fact that the areas of concentration of corals and sponges are relatively small (e.g., coral/sponge closure areas compose about 2.4% of the Project Area). Furthermore, it is likely that these colonies do not completely blanket the sea bed even in areas of concentration and thus the risk of encountering them is correspondingly small. For these reasons and the degradable nature of the anchors, it was predicted that any effects from the anchors will be *not significant*.
>
> Table 5.3 already shows the anchor placement as a separate activity: "Receiver Retrieval (anchors in place) Smothering (N)". For clarity, replace "anchors in place" with "anchor abandonment".
>
> The following bullet can be added to Table 7.1 under Seabed Disturbance:
>
> - Anchor abandonment NS 3

Section 5.7.1 CSEM Survey Components, second paragraph, first sentence, pg 141 – Remove the word "quickly" and replace it with "within a year" at the end of the sentence. "Quickly" is inaccurate because, as stated in section 5.7.4.3, the anchors will degrade within 9-12 months which can hardly be interpreted as "quickly".

> ***Response:*** Edit "quickly" to "within a year" in the first sentence of the second paragraph in Section 5.7.1, p.141.

Section 5.7.1 CSEM Survey Components, pg 141 – Sources of scientific proof on the degradation of the anchors is required. In addition, the proponent is asked to provide this proof to the C-NLOPB in the form of digital copies of the literature.

> ***Response:*** EMGS ASA commissioned SINTEF to develop an anchor that would degrade to sand within one year. The resulting report is entitled: "Controlled Deterioration of Non-reinforced Concrete Anchors - SINTEF Report STF22 F04624, October 2004" (see Appendix 1). The concept and veracity of this report were subsequently confirmed by Det Norske Veritas (DNV), an independent third party (see Appendix 2).

Section 5.7.2.1 EM Background Information, 7th bullet, pg 143 – How is "*To our knowledge...frequency electromagnetic radiation*" one of the basics of electromagnetic physics such as Faraday's Law. Further information should be provided to support this statement.

> ***Response:*** The sentence does not imply that all of the bullets listed are basics of Faraday's Law. The sentence in question reads "In order to understand the potential effects of EM, it is first necessary to understand some basics of electromagnetic physics such as Faraday's Law. The major basic points include:"
>
> The last sentence in this list was considered a "basic" tenet of electromagnetics as most authors consider extremely low duration, very low frequency AC radiation as not harmful to marine animals (e.g., see reviews contained in Buchanan et al. 2006, 2011; Tsoflias et al. 2012; WHO 2005, 2007). As with most scientific conclusions in biology there remains some small degree of uncertainty because of course not all animals and life stages have been tested under all conditions.

Section 5.7.2.3 Commercial Fisheries VEC, pg 146 – This section needs to be expanded to at least indentify (sic) the typical targeted species and do they normally be affected by electromagnetic emissions.

> ***Response:*** Add to this paragraph the following sentences:
>
> "Northern shrimp and snow crab form the bulk (about 85%) of the domestic commercial catch in the Study Area. The domestic harvest catch weight in the Study Area was dominated by northern shrimp (~66%) and snow crab (~19%) during this period, followed by Greenland halibut (~5%), cockles (~4%), and yellowtail flounder (~3%) (Table 4.2). While most of these species have not been specifically tested with electromagnetic sensitivity, it can be plausibly inferred from studies on related species that these species are likely not sensitive to short duration, very low frequency AC electromagnetic emissions."

Section 5.7.4.3 Geographic Extent – Receivers/Anchors, pg 149 – "*Based on EMGS' experience with returns of receivers washed up on the beach, the anchors will all degrade within 9-12 months*". Additional information, including references, is required to support this statement. This comment is also applicable for Section 5.7.4.4.

> ***Response:*** EMGS ASA commissioned SINTEF to develop an anchor that would degrade to sand within one year. The resulting report is entitled: "Controlled Deterioration of Non-reinforced Concrete Anchors - SINTEF Report STF22 F04624, October 2004" (see Appendix 1). The concept and veracity of this report were subsequently confirmed by Det Norske Veritas (DNV), an independent third party (see Appendix 2).

Section 5.7.6 Effects on Fisheries, pg 153 – Have the effects of the physical presence of the anchors left in various depths of water throughout the Project Area been considered in the assessment of effects on commercial fisheries.

> ***Response:*** Yes, in Section 5.7.6, as follows: "As discussed above, effects on Fish and Fish Habitat by the Project from waste management, the EM source, underwater sound, receiver deployment and retrieval, light attraction, and vessel/gear presence were all predicted to be *negligible* and thus *not significant*. As a result, any indirect effects on the fisheries caused by these components will be *negligible* as well, with the possible exception of vessel/gear presence (see Table 5.3)."
>
> See also response to Section 5.7 comment above. Anchors were considered under "retrieval" which is now termed "anchor abandonment" in Table 5.3.

Section 5.7.7.1 Waste Management, pg 154 – It should read, "...and seabirds VEC (see Table 5.2), *however*, the relatively..."

> ***Response:*** Edit "…and seabirds VEC (see Table 5.2), However, the relatively…" to "…and seabirds VEC (see Table 5.2), however, the relatively…" in Section 5.7.7.1, p.154.

Section 5.7.7.3 Underwater Sound, pg 154 – References need to be provided to justify the contents of the last two sentences.

> ***Response:*** The effects of underwater sound on birds in general have not been well studied. One study of the effects of underwater seismic survey sound on moulting Long-tailed Ducks in the Beaufort Sea showed little effect on their behaviour (Lacroix et al. 2003). The prediction of *negligible* effects on seabirds from underwater vessel noise is based on the fact that many seabirds appear undisturbed by, and are often attracted by vessels at sea and feed directly in the vessels' wakes.

Section 5.8 Unexploded Explosive ordnance, last paragraph, pg 164 – It should be *non-interfering*.

> ***Response:*** Edit "…may be operating near the area in a non-interferring manner" to "…may be operating near the area in a non-interfering manner" in the last paragraph in Section 5.8, p.164.

Environment Canada (EC) – Canadian Wildlife Service (CWS)

Section 2.12 Helicopters, pg 10 - Aircraft, particularly helicopters, have been known to cause significant negative impacts to migratory birds during various life stages (i.e. chick rearing, moulting). Mitigation measures such as timing and adjusting the altitude and pattern of helicopter flight lines can minimize disturbance. Helicopter use near seabird breeding colonies should be avoided from May 1st – August 31st (with an end-date of September 30th for Northern Gannet Colonies).

> ***Response:*** Helicopters associated with the Project will not cause any effects on nesting seabirds. The following text should be added to Section 5.7.7 of the EA related to the potential effects of the Project on seabirds:
>
> "Helicopters can have a significant negative impact on nesting seabirds. The Seabird Ecological Reserve Regulation under the *Wilderness and Ecological Reserves Act* states that aircraft should remain at least 300 m from a Seabird Ecological Reserve during the nesting season. The Witless Bay Ecological Reserve will be avoided during the nesting season between 1 May and 31 August, and the Cape St. Mary's Ecological Reserve will be avoided during the nesting season between 1 May and 30 September. For more information, see Environment Canada's guidelines related to the avoidance of disturbance to seabird and waterbird colonies in Canada at the following website: http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=E3167D46-1.

Section 4.5.1 Information Sources, pg 101 - It should be noted in this section that the ECSAS program is ongoing. Updated information in the region that have been collected since the publication of Fifield et al. (2009) can be obtained by contacting Carina Gjerdrum, EC-CWS pelagic seabird biologist, at Carina.gjerdrum@ec.gc.ca.

> ***Response:*** These data have not been analysed by CWS. Insert the following text in Section 4.5.1 of the EA after the second sentence of the first paragraph:
>
> "The relevant ECSAS survey data collected since the publication of Fifield et al. (2009) have not yet been analysed."

Section 4.6 Species at Risk, pg 116 - The Ivory Gull is listed as Endangered under the *Species at Risk Act*. The Ivory Gull recovery strategy has been finalized and is currently available at the Species at Risk Registry (see http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=50).

> ***Response:*** The sentence in Section 4.6 of the EA, "A recovery strategy has also been proposed for the Ivory Gull (Environment Canada 2013) should be revised as follows:
>
> "The Ivory Gull recovery strategy (Environment Canada 2014) has been finalized and is available at the Species at Risk Registry (see http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=50)."

Section 4.7.4 Important Bird Areas, pg 125 - The Cape St. Francis (NF021), Cape Pine and St. Shotts Barren (NF015) and the Mistaken Point (NF024) Important Bird Areas should be added to this section.

> ***Response:*** Cape St. Francis, Cape Pine and St. Shotts Barren, and Mistaken Point are designated Important Bird Areas (IBAs) for species that are not relevant to the proposed project. Cape St. Francis and Mistaken Point are designated IBAs for the numbers of Common Eiders (overwintering, spring migration) and Purple Sandpipers (overwintering) they support. The Cape Pine and St. Shotts Barren IBA is important for the number of American Golden-Plovers that stage there during fall migration. Those species are primarily coastal (Common Eider) or littoral/terrestrial (Purple Sandpiper, American Golden-Plover) species. The proposed project would occur during the period 1 May to 30 November during any one year. That period is outside the period during which the peak numbers of overwintering Common Eiders and Purple Sandpipers occur. It does overlap when American Golden-Plovers stage at the Cape Pine and St. Shotts Barren IBA, but golden-plovers stage on the uplands, not offshore. None of these sites are designated IBAs because of seabird colonies. Consequently, the text in Section 4.7.4 remains the same.
>
> Mistaken Point supports moderate numbers of some colonial seabirds. We have added Mistaken Point to Figure 4.37 and updated Table 4.12 with the data for Mistaken Point. The Proponent contacted CWS for confirmation of the rationale guiding the addition of the Mistaken Point IBA rather than all three of the IBAs from the above comment.

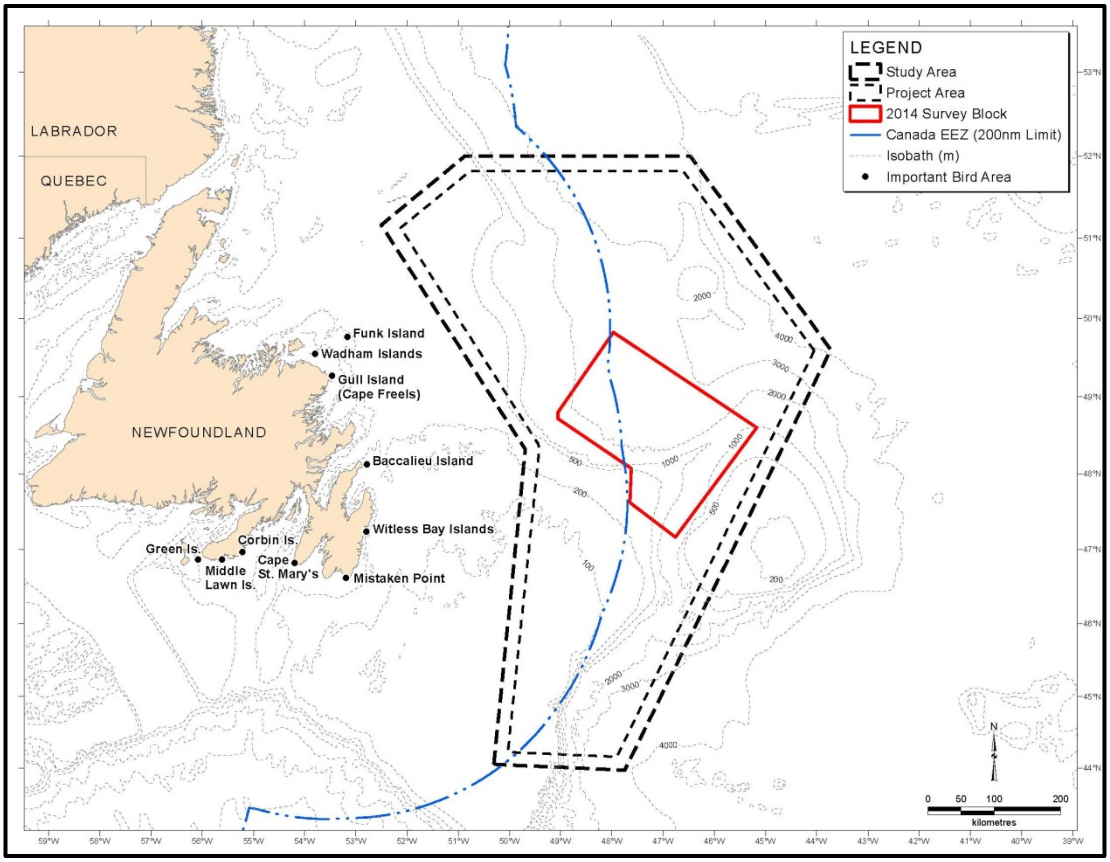

Figure 4.37. Eastern Newfoundland Important Bird Areas Relevant to the Project.

Table 4.12. Numbers of Pairs of Marine Birds Nesting at Marine Bird Colonies in Eastern Newfoundland.

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Mistaken Point	Witless Bay Islands	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Northern Fulmar	-	6[N]	-	12[A]		22[A,F]	Present[A]	-	-	-
Manx Shearwater	-	-	-	-		-	-	13[K, O]	-	-
Leach's Storm-Petrel	1,038[D]	-	250[J]	3,336,000[J]		667,086[H,I,J]	-	13,879[H]	100,000[J]	103,833[M]
Northern Gannet		9,203[N]		2,564[N]		-	14,789[L]	-	-	-
Herring Gull	-	500[J]	-	120[N]		4,638[E,J]	Present[J]	20[J]	5,000[J]	Present[M]
Great Black-backed Gull	Present[D]	100[J]	-	6[N]		166[E,J]	Present[J]	6[J]	25[J]	-
Black-legged Kittiwake	-	95[N]	-	5,100[N]	4,750[P]	23,606[F,J]	10,000[J]	-	50[J]	-
Arctic and Common Terns	376[J]	-	250[J]	-		-	-	-	-	-
Common Murre	-	412,524[C]	2,600[J]	1,500[N]	~100[P]	83,001[F,J]	15,484[J]	-	-	-
Thick-billed Murre		250[J]	-	75[N]		600[J]	1,000[J]	-	-	-
Razorbill	273[D]	200[J]	25[J]	500[N]	Present[P]	676[F,J]	100[J]	-	-	-
Black Guillemot	25[J]	1[J]	-	150[N]	Present[P]	20+[J]	Present[J]	-	-	-
Atlantic Puffin	6,190[D]	2,000[J]	20[J]	30,000[J]	50[Q]	272,729[F,G,J]	-	-	-	-
TOTALS	7,902	424,879	3,145	3,376,027		1,052,546	41,373	13,918	105,075	103,833
	Sources: A Stenhouse and Montevecchi (1999); B Chardine (2000); C Chardine et al. (2003); D Robertson and Elliot (2002); E Robertson et al. (2001); F Robertson et al. (2004); G Rodway et al. (2003); H Robertson et al. (2002); I Stenhouse et al. (2000); J Cairns et al. (1989); K Robertson (2002); L CWS (unpubl. data); M Russell (2008); N CWS 2012 (unpubl. data); O Fraser et al. 2013; P Parks and Natural Areas (unpubl. data); Q Cairns et al. (1989).									

Section 5.7.7.5 Light Attraction, third paragraph, pg 155 - Quote: "EMGS acknowledges that a CWS *Bird Handling Permit* will be required."

The permit should be referred to as a *Migratory Birds Convention Act* (MBCA) permit, not a Canadian Wildlife Service (CWS) permit.

> ***Response:*** The sentence in Section 5.7.7.5 of the EA, "EMGS acknowledges that a *CWS Bird Handling Permit* will be required" should be revised as follows:
>
> "EMGS acknowledges that a *Migratory Birds Convention Act* permit will be required."

Section 6.2 Seabirds, pg 170 - The permit should be referred to as a *Migratory Birds Convention Act* (MBCA) permit, not a Canadian Wildlife Service (CWS) permit.

> ***Response:*** The sentence in Section 6.2 of the EA, "It is understood by EMGS that a CWS *Migratory Bird Handling Permit* will be required and this will be secured by EMGS" should be revised as follows:
>
> "It is understood by EMGS that a *Migratory Birds Convention Act* permit will be required and this will be secured by EMGS."

Fisheries and Oceans Canada (DFO)

Section 4.3.2 Regional NAFO Fisheries, pg 51 - This section should include reference to the current version of NAFO closed areas effective as of January 2014 which are available from the Fisheries Management Division of DFO.

> ***Response:*** Many of the NAFO closed areas are covered in Section 4.7 (Sensitive Areas) and illustrated in Figure 4.36 (p.125-126) of the EA. However, amend Section 4.3.2 (Regional NAFO Fisheries) to include a reference to the most recent NAFO Conservation and Enforcement Measures document (NAFO 2014) which lists the coordinates for closed areas within the Study Area, such as ecologically and biologically sensitive areas (EBSAs), cod box, and seamount, coral and sponge protection zones (Article 16 – p.19-24 *in* NAFO 2014). Also, amend Section 4.3.2 to include the Orphan Knoll as a NAFO closed area. This area is 15,771 km^2 and the coordinates may be found on p.19 of NAFO (2014). These closed areas prohibit the use of bottom fishing gear until at least December 31, 2014.

Section 4.3.3.2 Analysis of Recent Commercial Catches and Section 4.3.3.3 Analysis of Commercial Catches in 2014 Survey Block, pgs 53-55 - While this section of the report notes the predominance of shrimp by weight in terms of overall catch up to 2010, it is felt that it should be updated to 2012 to reflect changes in shrimp activity specifically noting closure of 3M shrimp in 2011 and reduction in 3L shrimp TAC in recent years.

> ***Response:*** DFO only provides georeferenced commercial catch and effort datasets up to 2010; 2011 and 2012 catch data were provided by DFO as ranges of catch weights and

catch values within 6 min × 6 min cells (latitude × longitude). Figure 4.7, p.58, which was based on these 2011 and 2012 commercial fishery databases for northern shrimp, were included in the EA.

Amend Section 4.3.3.4, *Northern Shrimp*, p.56, to indicate the changes in the TAC of 3L and 3M northern shrimp. Specifically, the TAC for 3L shrimp has declined from 30,000 t in 2010 to 19,200 t in 2011, from 12,000 t in 2012 to 8,600 t in 2013, and to 4,300 t in 2014. There has been no directed fishery for 3M shrimp since the 3M shrimp fishery closure in 2011.

Section 4.2.4 Fisheries - American Plaice, pg 42 - The description provided for American Plaice should note that a moratorium is in place for 3LNO and 3M stock areas.

Response: Amend Section 4.2.4, *American Plaice*, p.42, to indicate that a moratorium is in place for American plaice in NAFO Divisions 3LNO and 3M.

The Div. 3LNO population of American plaice is the largest in Newfoundland and Labrador, and is considered to have been historically the largest flatfish population in the northwest Atlantic (DFO 2012). Over a 47-year time series, abundance has declined by approximately 96%. The primary factor thought to be responsible for the decline of American plaice stocks is overfishing, although increased natural mortality may also have played a role, particularly in Div. 2J3K and Div. 3LNO (COSEWIC 2009). COSEWIC last assessed the Newfoundland and Labrador American plaice population in 2009 and determined that the decline in plaice appeared to have ceased, however, numbers remained below a precautionary threshold estimated for this stock. They also stated that some significant and poorly regulated bycatches are negatively influencing recovery. Further adding to the problem of bycatch are fishing gears that are size selective, cropping large individuals and reducing population reproductive potential. There has also been evidence of increased natural mortality which has slowed the recovery of Newfoundland and Labrador's American plaice population (COSEWIC 2009).

NAFO's most recent assessment of American plaice in Div. 3LNO and 3M occurred in 2011, concluding that both stocks are in poor condition and the moratorium should be upheld.

Section 5.7.2 Review of Effects of Electromagnetic Emissions, pgs 143 – 147 - The report should review and consider the potential for CSEM to impact functions (other than migration and prey detection) in the life history of marine fish, invertebrates and mammals. The review of potential impacts of CSEM on marine biota provided in Section 5.7.2.2 - 5.7.2.7 should be expanded where possible based on information which may come out of such review and consideration.

Response: There is a large volume of literature (more than 25,000 publications—WHO 2005, 2007) concerning the potential biological effects of non-ionizing radiation (i.e., low frequency radiation, not strong enough to break molecular bonds). Primary focus has been on human health issues such as reproduction, fetal development, cataracts, cancer, headaches, and many others.

Fisher and Slater (2010) examined over 50 publications for a literature review on the effects of EMFs on marine species, and compared results from 20 or so studies that tested a variety of invertebrate and vertebrate species with various electric and magnetic fields. Studies tested for mortality, physiological, and behavioural effects. Only a few of these studies used EMF strengths somewhat analogous to those produced during CSEM, and of these few studies only the sharks, skates, and rays showed any responses and these were limited to non-lethal effects on heart rates and orientation behavior (Table 1 *in* Fisher and Slater 2010).

Another recent review of 113 peer-reviewed publications on the effects of radiofrequency electromagnetic fields on fertility, reproduction, behaviour and development of a wide variety of organisms by Cucurachi et al. (2013) concluded that "no clear dose-effect relationship could be discerned" (see their summary in Table 7 below). It is important to note in reviewing the literature on EMFs that much of the effects literature stems from laboratory studies that used DC current, often of higher frequency than CSEM, with typical durations of hours or days. Towed CSEM uses very low frequency AC current and exposure times of marine animals would normally be on the order of minutes. The vast majority of existing research on the potential effects of EMFs is not directly relevant to CSEM.

As concluded by Cucurachi et al. (2013), physiological studies have provided mixed results. For example, they have reported both acceleration and slowing down of sea urchin embryo development. Static magnetic fields (not CSEM) have been reported to alter the early embryonic development in sea urchin embryos from *Lytechinus pictus* and *Strongylocentrotus purpuratus* by affecting the onset of mitosis (Levin and Ernst 1997 *in* Köller et al. 2006). Mussels (*Mytilus edulis*) have been subjected to static magnetic field conditions for three months and the determination of gonad index and condition index during the reproductive period in spring revealed no significant differences from the control group (Bochert and Zettler 2004 *in* Köller et al. 2006). Experiments involving cultured cells and animal models indicate that there is little to no evidence that extremely low frequency EMF causes damage to chromosomes or affects cell division or other cellular functions (Acres 2006 *in* OSPAR 2008).

Most current reviewers conclude that exposure to very low frequency, low intensity AC electrical or magnetic fields has minimal health risk to marine animals (e.g., see Buchanan et al. 2006, 2011; Tsoflias et al. 2012; Woodruff et al. 2012). However, they do not rule out future discoveries of risk from chronic long term exposure. Human health guidelines cited in WHO (2005) list limits for the general public of 100 µT (500 µT for workers) at 50 Hz (83 µT at 60 Hz) for magnetic fields and 5,000 V/m for electrical fields. These levels are well above what would be generated by CSEM. For example, a typical CSEM source might generate 2,282 nT at 0.1-2 Hz whereas in comparison a computer might generate 2,500 nT at 3×10^6 Hz. Thus, it is reasonable to predict that low frequency CSEM covering a small area over a short period of time will have no discernible health effects on marine biota (including fish eggs) in the Project Area and thus direct health effects were not considered in the EA. Potential concerns do exist in regard to animals that may use geomagnetism to assist navigation or electro-reception to assist in finding food. As a result, these aspects were the focus of the EA and were discussed in detail. This approach is in keeping with that taken by major reviews of potential effects of underwater power cables (e.g., Normandeau et al. 2011; Woodruff et al. 2012; Gill et al. 2013). Any effects, however localized, from permanent AC or DC underwater cables would be expected to be greater than any from towed CSEM.

Table 7. Analysis of Differences in Articles between RF-EMF Effect and No-effect Studies. Source: Cucurachi et al. (2013).

Parameter	Effect	No effect
Country (number) [a]		
USA	18	17
India	8	3
Greece	8	2
France	5	8
Croatia, China, Germany, Latvia, Spain and UK	3	
Canada, Japan, and Switzerland	2	
Others	10	12
Exposure duration (min) [b]		
Mean	146,960.5	63,241.26
Median	1800	1800
Mode	30	300
Standard deviation	836,108.1	232,212.2
Sample variance	6.99E + 11	5.39E + 10
Minimum	5	0.0875
Maximum	7,257,600	1238,400
Based on number of articles	79	39
Frequency ranges (MHz) (number) [c]		
0-30	3	2
31-200	7	2
201-900	38	9
901-1200	7	1
1201-1800	4	5
1801-2000	3	4
>2000	19	16
Journal Impact Factor [d]		
Mean	2.079973	2.449725
Median	2.291	2.371
Mode	0.73	2.291
Standard deviation	1.094949	0.897919
Sample variance	1.198914	0.806259
Minimum	0.13	0.246
Maximum	4.411	4.411
Based on number of articles	73	40

[a] Country: location of the university where main author or research group are based. Data tested by Fisher Exact Test (p-value = 0.1595).

[b] Exposure duration (min): duration of exposure of target subject in minutes as reported by author. Data tested by Kruskal-Wallis (p-value = 0.9514).

[c] Frequency ranges (MHz): type of RF-EMF frequency ranges applied in studies. Data tested by Fisher Exact Test (p-value = 0.03531).

[d] Journal Impact Factor: impact factor of journal of publication, if available, of RF-EMF study as reported by Journal of Citation Reports on the Web (JRC WEB). Data tested by Kruskal-Wallis (p-value = 0.3233).

Section 4.2.4.2 Other Fishes Caught in the Commercial Fishery, pgs 40 – 48 - The *SARA* and COSEWIC status for each relevant species described should be included in their respective paragraphs in this section. Smooth Skate should also be discussed in this section as the Funk Island Deep population could be present in the Study Area.

Roundnose Grenadier should be discussed in this section as the species could be present in the Study Area.

> ***Response:*** Amend each species listed in Section 4.2.4.2 (Other Fishes Caught in the Commercial Fishery), p.40-48, to include their respective COSEWIC-assessed and *SARA*-listed status. See Table 1 below.

Table 1. *SARA*-listed and COSEWIC-assessed Species Harvested in the Commercial Fisheries that Occur in the Study Area.

Species	Population	COSEWIC Status	*SARA* Status
Acadian redfish (*Sebastes fasciatus*)	Atlantic population	Threatened	No Status
Deepwater redfish (*Sebastes mentella*)	Northern population	Threatened	No Status
Atlantic cod (*Gadus morhua*)	Newfoundland and Labrador population	Endangered	No Status
American plaice (*Hippoglossoides platessoides*)	Newfoundland and Labrador population	Threatened	No Status
Thorny skate (*Amblyraja radiate*)	No listing	Special Concern	No Status
Smooth skate (*Malacoraja senta*)	Funk Island Deep population	Endangered	No Status
Roughhead grenadier (*Macrourus berglax*)	No listing	Special Concern	No Status
Roundnose grenadier (*Coryphaenoides rupestris*)	No listing	Endangered	No Status
Capelin (*Mallotus villosus*)	No listing	No listing	No listing
Blue hake (*Antimora rostrata*)	No listing	No listing	No listing
Winter flounder (*Glyptocephalus cynoglossus*)	No listing	No listing	No listing
Atlantic wolffish (*Anarhichas lupus*)	No listing	Special Concern	Special Concern, Schedule 1
Northern wolffish (*Anarhichas denticulatus*)	No listing	Threatened	Threatened, Schedule 1
Spotted wolfish (*Anarhichas minor*)	No listing	Threatened	Threatened, Schedule 1

Sources: *SARA* website (http://www.sararegistry.gc.ca/default_e.cfm) (as of 23 May 2014); COSEWIC website (http://www.cosepac.gc.ca/index.htm) (as of 23 May 2014).

Amend Section 4.2.4.2 (Other Fishes Caught in the Commercial Fishery), p.40-48, to include species descriptions of smooth skate and roundnose grenadier (see below). The smooth skate description was obtained from the Southern Newfoundland Strategic Environmental Assessment (SEA) (LGL 2010) while roundnose grenadier description was obtained from the recently completed EA for MKI's Labrador Sea Seismic Program 2014-2018 (LGL 2014).

Smooth Skate

Smooth skate (*Malacoraja senta*) are found along the Atlantic coast of North America ranging from the Gulf of St. Lawrence and Labrador shelf to South Carolina (Packer et al. 2003 *in* JW 2007). The Funk Island Deep population is designated as *endangered* by COSEWIC. Smooth skate typically live on soft mud and clay bottoms, frequently in deep troughs and basins (Scott and Scott 1988). Smooth skate occur at depths ranging from 46 to 457 m and are most abundant below 110 m, and are common in the deep waters along the slope of the Laurentian Channel (Swain and Benoit 2001 *in* JW 2007). One of the five areas (i.e., Designatable Units or DUs) of relatively high concentration of smooth skate is identified as 'Northeast Scotian Shelf / Laurentian Channel / Southwest Grand Banks' which occurs within the SEA Area (Kulka et al. 2006; DFO 2006).

There is limited information regarding the life history of the smooth skate. The diet of smooth skate is comprised of amphipods, mysids, decapods, euphausiids, and fish species, including yellowtail flounder, hake, witch flounder, and sand lance (Packer et al. 2003 *in* JW 2007).

Using DFO multispecies survey trawl data for Div. 3NOPs4VWT, Kulka et al. (2006) showed that the adult portion of the Laurentian DU within the SEA Area declined by 73% between 1971 and 2005. It should be noted that abundance trends were not consistent throughout the area and not all areas of the DU were included in the integrated analysis in the early period. Thus, the long term decline rate is influenced by areas where the decline appears to have been greatest: in the southern Gulf and Scotian Shelf (Kulka et al. 2006).

Roundnose Grenadier

Roundnose grenadier (*Coryphaenoides rupestris*) is designated as *endangered* by COSEWIC. This designation is based on declines of roundnose grenadier in both DFO RV fall bottom trawl surveys in NAFO Divisions 2J3KL and in commercial catch rates. Populations of roundnose grenadier have declined by more than 95% since 2000 (COSEWIC 2008).

Distributed in the northwest Atlantic from Cape Hatteras to Greenland, the roundnose grenadier is a deepwater, demersal fish found in continental slope areas at depths of 180 to 2,600 m, but primarily occurs between 400 to 1,200 m (DFO 2010). DFO RV surveys indicate catches are concentrated along the perimeter of the continental slope in NAFO Divisions 2HJ3KLNO. This species is thought to undergo seasonal migrations, with individuals in northeast Newfoundland and Labrador waters occupying deeper water in winter and shallower water in late summer, possibly due to prey availability and/or temperature differences (DFO 2010). Roundnose grenadier prefer a temperature range of 3.5 to 4.5°C and will form dense aggregations in areas where warm water lies directly above the seabed. They appear to prefer areas with weak currents and tend to aggregate in troughs, gorges, terraces, and lower parts of the slope (DFO 2010). Diurnal vertical migrations also occur that may carry them more than 1,000 m off the bottom (COSEWIC 2008). This long-lived, late-maturing, slow-growing species has a low fecundity and is potentially vulnerable to overfishing (Devine and Haedrich 2008). The roundnose grenadier harvest has been under a moratorium in Canadian waters in NAFO Subareas 2 and 3 since the 1990s, and is currently under moratorium in NAFO Subarea 0 as well. Roundnose grenadier is harvested as bycatch in other fisheries (e.g., Greenland halibut fishery); both within and beyond the 200 mile limit (Power 1999; DFO 2010). Population models indicate that current bycatch levels appear to be sustainable, but reductions in bycatch of roundnose grenadier could aid in the recovery of stocks (DFO 2010).

This species is known as a batch spawner, releasing eggs in more than one spawning event per spawning season (DFO 2010). Roundnose grenadier spawning grounds are largely unknown, but are suspected to be in waters deeper than 850 m. Spawning is believed to occur either in different areas throughout the northwest Atlantic (COSEWIC 2008) or predominately in Icelandic waters, from which eggs and larvae are carried to other areas in the northwest Atlantic by currents (Scott and Scott 1988). The spawning time is uncertain but believed to be throughout the year, with more intense spawning during particular periods (Atkinson 1995). Roundnose grenadier feed on a variety of small crustaceans and euphasiids, squid, and small fishes. Their main predators include at least two species of redfish and blue ling (*Molva dypterygia*) (Kearley 2012).

Despite large declines in the roundnose grenadier resource in the early 1990s, recent trends in abundance in Div. 2J3K from 1995-2009 suggest that catch rates are potentially increasing (DFO 2010).

Table 4.8, pgs 89-90 - The applicable population names for each species should be included in this table. The Atlantic population of Sei Whale is a high priority candidate species under COSEWIC. It should be noted that Sperm Whale is a mid-priority candidate species, and Harp Seal and Hooded Seal are both high priority candidate species under COSEWIC as such Table 4.8 should be amended accordingly.

Response: The *SARA*-listed and COSEWIC-assessed species in Table 4.8, p.89-90, are in reference to populations that occur within the Study Area. Revise Table 4.8 to include: the Atlantic population of sei whale (*Balaenoptera borealis*) as “HPC” (*high priority candidate*), sperm whale (*Physeter macrocephalus*) as “MPC” (*mid-priority candidate*), and both harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals as “HPC” under COSEWIC.

Section 4.4.1.4 Sperm Whale, pg 94 - Sperm Whale is a mid-priority candidate species under COSEWIC as such the 3rd sentence of this section should be amended accordingly.

> ***Response:*** Edit the third sentence in Section 4.4.1.4, *Sperm Whale*, p.94 from "They are currently considered a *low priority candidate* species by COSEWIC" to "They are currently considered a *mid-priority candidate* species by COSEWIC."

Section 4.4.1.5 Hooded Seal and Harp Seal, pg 99 - Hooded Seal and Harp Seal are both high priority candidate species under COSEWIC as such the descriptions provided for both species should be amended accordingly.

> ***Response:*** Edit the last sentence in the first paragraph in Section 4.4.1.5, *Harp Seal*, p.99, from "COSEWIC is considering the harp seal as a *mid-priority candidate* species" to "COSEWIC is considering the harp seal as a *high priority candidate* species." Similarly, edit the second sentence in Section 4.4.1.5, *Hooded Seal*, p.99, from "Hooded seals have no status under *SARA* and are considered *not at risk* by COSEWIC; however, they are currently a *mid-priority candidate* species" to "Hooded seals have no status under *SARA* and are considered *not at risk* by COSEWIC; however, they are currently a *high-priority candidate* species."

Table 4.14, pg 117 - The row containing Atlantic Cod listed on Schedule 3 of *SARA* (sic) should be removed from the *SARA* (sic) column and placed in the appropriate COSEWIC column.

> ***Response:*** To clarify, the row containing Atlantic cod as listed on Schedule 3 of *SARA* in Table 4.14, p.117, is a general designation of the species as a whole (i.e., all populations of Atlantic cod). COSEWIC does not specify a status for a species without a specific population indicated (when considering multiple populations of a given species; see the *SARA* website [http://www.sararegistry.gc.ca/default_e.cfm]). The COSEWIC status (*endangered*) of the Newfoundland and Labrador population of Atlantic cod may be found below the above mentioned row. Therefore, it is not necessary to apply changes to Table 4.14.

Section 4.7.1 Integrated Management Areas, pgs 126 -127 - The study area includes a portion of the NL Shelves Bioregion as well as the Placentia Bay Grand Banks Large Ocean Management Area (PBGB LOMA). It should be clarified that the two areas are different in nature and extent. The following reference gives some insight into the Bioregion and contains information that may be useful in describing the differences.

DFO. 2009. Development of a Framework and Principles for the Biogeographic Classification of Canadian Marine Areas. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/056. The LOMA description seems a bit dated. The following current DFO website may help http://www.dfo-mpo.gc.ca/oceans/planning/index-eng.html. In particular the following text may be of use in clarifying the description.

Oceans Planning - To protect and manage our oceans, Canada has identified particular bodies of water as priority areas. Five Large Ocean Management Areas (LOMAs) have been established to focus on areas *under pressure from human activities and to address key conservation challenges. DFO is learning how to apply the integrated management planning approach within these areas before broadening the approach elsewhere. While LOMAs have been the focus of attention in past years, Canada is also developing a marine protected areas network, involving all levels of government, to ensure a comprehensive approach to protecting marine areas. Applying different policy tools and approaches to these areas helps to balance the need to protect the marine environment from the impact of human and industrial activities that take place within these areas, thus taking an integrated oceans management approach to ocean planning. Decisions about ocean resources must take into consideration the long-term, direct and indirect impacts on social, economic and environmental systems. 2nd sentence 3rd paragraph page 127 - this sentence notes that "The designation of EBSAs is a tool to allow appropriate management of geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics (DFO 20130)".* This reference (DFO. 2013a. Assessment of Divisions 2G-3K northern shrimp. DFO Can. Sci. Advis. Sci. Stock Advis. Rep. 2013/012) does not appear to be the relevant reference for the statement and this inconsistency should be corrected accordingly.

> ***Response:*** As stated in the EA, the Ecologically and Biologically Significant Areas (EBSAs) that occur within the Study Area represent portions of the Newfoundland and Labrador Shelves Bioregion within which the Placentia Bay-Grand Banks Large Ocean Management Area (LOMA) occurs. Bioregions are high-level spatial units associated with Canada's three oceans, and are primarily based on oceanographic and bathymetric similarities (DFO 2009). The PB-GB LOMA was established, along with four other LOMAs, to provide focus on areas under pressure from human activities and to address key conservation challenges. DFO is currently learning how to apply the integrated management planning approach within these five LOMAs before broadening the approach elsewhere.
>
> The reference associated with the second sentence of the third paragraph on p.127 of the EA should be DFO (2013g).

Section 4.7.2 Coral and Sponge Areas, pg 128 - Figure 4.36 caption notes that the figure describes *"the locations of these* 12 *areas, eight of which occur entirely partially within the proposed Study Area".* There would appear to be something missing from this sentence and it is suggested to clarify by adding "*...entirely or partially ..."*

> ***Response:*** Edit "…locations of these 12 areas, eight of which occur entirely partially within the proposed Study Area" to "…locations of these 12 areas, eight of which occur entirely or partially within the proposed Study Area" in Section 4.7.2, p.128.

Figure 4.36, pg 126 - The caption of needs to be changed as it refers to the NL Shelves EBSA should be plural (EBSAs).

> ***Response:*** Revise the figure caption for Figure 4.36, p.126, to the following:
>
> "Locations of the NL Shelves EBSAs, PBGB LOMA EBSAs, Bonavista Cod Box, and NAFO Coral/Sponge Closure Areas Relative to the Study Area."

Section 5.5 –Mitigations, pg 139 - Although this is not a seismic survey program environmental assessment some of the mitigation measures provided for within the "Statement of Canadian Practice with Respect to Mitigation of Seismic Sound in the Marine Environment" (SOCP) may be applicable. The proponent should be required to adhere to all applicable minimum mitigations outlined in C-NLOPB Guidelines and the SOCP as well as those described in the EA page 139. This section should be amended accordingly.

> ***Response:*** Under bullet list, edit: "**Marine Mammals and Sea Turtles**. Electromagnetic source will be turned off during vessel turns; environmentally benign anchors will be used. Marine mammal observers will be utilized to oversee ramp-up procedures if required" to "**Marine Mammals and Sea Turtles**. Electromagnetic source will be turned off during vessel turns. Environmentally benign anchors will be used. In all areas, the electromagnetic source will be ramped up over a 20 minute period."

Section 5.7.10 Effects on Species at Risk, pgs 161-163 - The effects assessment for species at risk only includes threatened and endangered species on Schedule 1 of *SARA*. This assessment should include all species listed on Schedule 1 of *SARA* (i.e., endangered, threatened and special concern). Page 161 states, *"The probability of encountering these species in the Study Area* is *low because they are rare, and in some cases would be at the limits of their present range..."* Although it may be unlikely that some of the species listed in this section would be present in the study area, it is important that the proponent employs all applicable mitigation measures as it is still possible that an individual could be encountered throughout the duration of the project.

> ***Response:*** Please add *SARA* Schedule 1 s*pecial concern* species, fin whale (Atlantic population), Sowerby's beaked whale, and Atlantic wolffish to the list of species in this section. The assessment remains unchanged.

Section 5.7.11 Sensitive Areas, pg 164 - This section states, in error, that the study area includes portions of two DFO EBSAs (PBGB and NL Shelves). Neither of these areas are EBSAs rather the PBGB (Placentia Bay Grand Banks) is a Large Oceans Management Area (LOMA) and the Newfoundland Labrador Shelf is a Bioregion as referenced in CSAS report DFO Can. Sci Advis. Sec. Sci. Advis. Rep. 2009/056 and as noted above in comments on Section 4.7.1. The description provided in Section 5.7.11 should be amended accordingly.

> ***Response:*** The second sentence of the first paragraph of Section 5.7.11 should be revised as follows:
>
> "The Study Area includes Ecologically and Biologically Significant Areas (EBSAs) associated with the Newfoundland and Labrador Shelf Bioregion, including EBSAs that occur within the Placentia Bay-Grand Banks Large Oceans Management Area that constitutes part of the NL Shelf Bioregion."

Section 6.0 Mitigation and Follow-up, page 169 and Section 6.3 Fisheries, pg 170-171 - The description of specific mitigations provided for in the 2nd paragraph of page 171 and the reference to "avoidance of conflicts with survey vessels" provided in the 1st sentence of 3rd paragraph on page 171 should both apply to DFO - Industry Post Season Crab Surveys. Reference to same should be explicit within this section accordingly.

Response: Amend Section 6.3 in its entirety to read:

"6.3 Fisheries

Fishers who may be operating in the area will be notified of the timing and location of planned activities by means of a CCG "Notice to Mariners" and a "Notice to Fishers" on the CBC Radio Fisheries Broadcast. In addition, if necessary, individual fixed gear fishers will be contacted to arrange mutual avoidance. Any contacts with fishing gear, with any identifiable markings, will be reported to the C-NLOPB immediately. Fishing gear may only be retrieved from the water by the gear owner (i.e., fishing license owner). This includes buoys, radar reflectors, rope, nets, pots, etc. associated with fishing gear and/or activity. If gear contact is made during CSEM operations it should not be retrieved or retained by the CSEM vessel. There are conditions that may warrant gear being retrieved or retained if it becomes entangled with the CSEM streamer; however, further clarification on rules and regulations regarding fishing gear should be directed to the Conservation and Protection Division of Fisheries and Oceans Canada (NL Region). EMGS will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

Specific mitigations to minimize potential conflicts and any negative effects with other vessels include:

- The proposed survey area polygon for the 2014 campaign is indicated in Figure 1.1 of the EA. Any updates to this polygon will be submitted to the C-NLOPB at least 2 weeks prior to start-up and will be published in Notice to Fishery / Shipping in due time. Timely and clear communications (VHF, HF, Satellite, etc.) will be employed.
- Utilization of fisheries liaison officers (FLOs) for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- FLO onboard;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation in the event any project activities damage fishing gear [Compensation will be according to established procedures—e.g., C-NLOPB and C-NSOPB (2002) and One Ocean (2013).]; and
- Single Point of Contact (SPOC).

EMGS will also coordinate with DFO, St. John's, and the FFAW to avoid any potential conflicts with survey vessels (e.g., DFO - Industry Post Season Crab Surveys) that may be operating in the area. EMGS commits to ongoing communications with other operators with active geophysical programs within the general vicinity of its CSEM program to minimize the potential for cumulative effects on the VECs.

While this EA covers the Project from 2014 to 2018, details on any post-2014 surveys will be provided in EA validation documents to be submitted to the C-NLOPB."

Section 6.1 *SARA* Species, Including Marine Mammals and Sea Turtles, pg 170 - This section lists several mitigations that will be employed to protect species at risk. Although this is not a seismic program, some of the mitigations in the *"Statement of Canadian Practice with respect* to *the Mitigation of Seismic Sound in the Marine Environment"* (SOCP) may be applicable, as such the SOCP should be referenced in this section and the applicable mitigations adhered to. Any dead or distressed marine mammals, sea turtles, and other *SARA* species should also be reported to DFO, the last sentence of Section 6.1 should be amended accordingly.

Response: It should be reiterated that CSEM surveys are not analogous to seismic surveys which emit primarily low-frequency, strong sound pulses that can be heard by marine mammals at long range. Thus, the applicability and requirement to use mitigation measures in the SOCP for marine mammals and sea turtles during a CSEM survey offshore Newfoundland are questionable. Notwithstanding, EMGS will take a precautionary approach and apply "relevant" mitigation measures from the SOCP. Text from Section 6.1 of the EA should be amended as follows:

"6.1 *SARA* Species, Including Marine Mammals and Sea Turtles

Monitoring and mitigation measures designed to reduce potential effects of electromagnetic signals on sharks, marine mammals and sea turtles will include the following:

(1) In all areas, gradual ramp-up of the electromagnetic source will occur over a 20 min period;
(2) In areas where water depths are <500 m, no initiation of the EM source if a shark, marine mammal or sea turtle is observed 30 min prior to ramp-up within the 500 m safety zone of the energy source. Ramp-up would not commence until the animal has moved beyond the 500 m zone or 20 min have elapsed since the last sighting;
(3) In areas where water depths are <500 m, shut down of the energy source if a Schedule 1 (*SARA*) endangered (or threatened) animal is observed within the 500 m safety zone; and
(4) The observers will watch for shark, marine mammals and sea turtles when the source is active (during daylight periods) and systematically record the location and behaviour of these animals.

The planned monitoring and mitigation measures, including gradual ramp-ups, visual monitoring, and shutdown of the EM source when endangered or threatened marine animals are seen within the "safety radius" in areas where water depth is less than 500 m, will minimize the already-low probability of exposure of marine animals to EMFs strong enough to be detected. Any dead or distressed marine mammals or sea turtles, and *SARA* species, will be recorded and reported to the C-NLOPB and DFO."

CORRECTIONS TO THE ENVIRONMENTAL ASSESSMENT

Some errors were discovered by EMGS technical personnel in the Project Description. The following items refer to these errors and required revisions to the EA.

Section 2.9 (CSEM Streamer) – page 9 – 2nd sentence

The sentence "The flotation sections are segregated into five 50-m sections (containing 670 L each) and one 14-m section containing 187 L." should be changed to the following:

"The flotation sections are segregated into five to ten 50-m sections (containing 670 L each) and one 14-m section containing 187 L.

Table 5.1 (Project Components Unique to CSEM Surveys) – page 142

EMGS has made changes to the EM source level (1,250 A changed to 'up to 1,500 A'), source tow speed (changed from 2-3 kts to 2-5 kts), distance of source above seabed (changed from 30-50 m to 30-200 m), cable length (changed from 300 m to 600 m), and number of 50-m streamer sections (changed from five to 'five to ten'). Therefore, Table 5.1 should be revised as follows:

Table 5.1 Project Components Unique to CSEM Surveys.

Component	Number[a]	Description	Purpose	Interactions
EM Source	1	AC current, up to 1,500 A, extremely low frequency (variable, <20 Hz) (ELF); towed at 2-5 kts, (depending upon tension) 30-200 m above the seabed	Measure resistivity of underlying seabed in order to assist in discriminating oil from water.	Electromagnetic emissions can be detected by a variety of marine animals and some may react to them.
Streamer	1	Cable (0.7 m x 600 m); streamer of five to ten 50-m sections and 1 14-m section containing flotation fluid (670 L per 50-m section; 187 L per 14-m section), conductors, source anode and cathode.	Connect the source to vessel generators and to serve as conductor of source outputs.	Presence of towed cable. Potential for flotation fluid leakage.
Receivers	200	Small packages with 4 antennae, equipped with pingers and acoustic releases.	Set on seabed in grid pattern to collect electromagnetic signals.	Small, temporary disturbance of the seabed from anchors (see below).
Anchors	200	102 x 810 x 920 mm in dimension; compressed sand and other natural components. Degrades to sand within one year.	Temporarily anchor the receivers to the seabed.	Small, temporary disturbance (<1 y) of the seabed.

[a] These are the numbers of the various components that will be in use at any one time during operations.

The above-noted revisions do not change any of the predictions or conclusions contained in the original EA. The increase in amperage from 1,250 A to a maximum of 1,500 A increases the radius of the zone of influence of the generated magnetic field by 20% (EMGS data) from 400 m to 480 m. The radius of the zone of influence of the generated electric field as modeled by EMGS is 700 m (EMGS data) which falls within the 800 m radius used for effects predictions in the EA.

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Appendix 1

SINTEF Report

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REPORT

SØR-TRØNDELAG NOTARIUS PUBLICUS

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Det bekreftes at ....
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Anne-L. Halvorsen
bem.

Controlled Deterioration of Non-reinforced Concrete Anchors

Harald Justnes and Kåre Johansen

SINTEF Technology and Society
Concrete

October 2004

SINTEF

SINTEF REPORT

SINTEF

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Controlled Deterioration of Non-reinforced Concrete Anchors

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CLIENT(S)

EMGS – ElectroMagnetic Geoservices

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ABSTRACT

Efforts are normally made to avoid deterioration of concrete, but in this project the aim was to deteriorate concrete specimens within a year after submersion in seawater.

When including sufficient calcium carbonate in the concrete recipe, the concrete is susceptible to deteriorate by sulphate attack (e.g. from sea water) at low temperatures (< 15°C) since hydraulic CSH gel (i.e. main binder in cement paste) is transformed to thaumasite (a calcium silicate carbonate sulphate hydrate) without binding properties.

To speed up the deterioration rate, tests were also performed by adding calcium carbonate and anhydrite (i.e. calcium sulphate without crystal water) in stiochiometric ratio according to the thaumasite formula. These specimens deteriorated faster than specimens without anhydrite, since sodium sulphate from seawater has to diffuse into the porous concrete and react with the calcium hydroxide of the binder to form gypsum (i.e. calcium sulphate with two crystal water) *in situe* when anhydrite is not included.

The concrete was cured for 7 days in fresh water before exposure to seawater. When the amount of additives was increased, the 7 and 28 days compressive strength of the concrete decreased. The deterioration between 7 and 28 days exposure in sea water was limited. A recommended composition was found for concrete deteriorating completely in sea water after 4 months. The concrete contain no ingredients harmful to the environment.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Materials technology	Materialteknologi
GROUP 2	Concrete	Betong
SELECTED BY AUTHOR	Controlled deterioration	Kontrollert nedbrytning
	Compressive and flexural strength	Trykk- og bøyestrekkfasthet
	Thaumasite	Taumasitt

TABLE OF CONTENTS

1 INTRODUCTION AND BACKGROUND

EMGS-ElectroMagnetic Geoservices AS is a seabed logging company working for the oil industry. Seabed logging is based on electromagnetic waves and can determine whether the reservoir contains hydrocarbons or water.

Concrete anchor elements are strapped to the measuring devices and, together with floaters on top, they help to sink the devices in a stable manner and to secure a stable position at the seabed. After the measurements are finished, the device is released and floated to the surface leaving the concrete anchor behind. In order to prevent the concrete anchors to be obstacles for fisheries (e.g. trawling) at the same seabed, the concrete should disintegrate after some time. A secondary advantage of such an approach would be to ensure recovery of the expensive measuring devices after some time in cases where the release mechanism would fail.

SINTEF Civil and Environmental Engineering was first contacted by Spenncon 2003-06-12 outlining the issues.

2 OBJECTIVES

The main objective was to develop concrete that will disintegrate within a limited time after contact with water, preferably only in seawater.

The concrete composition should be limited to components that are not harmful to the environment (i.e. marine life).

3 PRINCIPLES OF CONCRETE DISINTEGRATION

The hydraulic binder of concrete based on Portland cement is amorphous calcium silicate hydrate (CSH-gel) where some 25% crystalline calcium hydroxide is embedded. Other less abundant minerals exist as well.

If sufficient calcium carbonate is added to such a concrete (e.g. as limestone filler), it is known that the concrete will be prone to degradation by sulphate attack at low temperatures (< 15°C), even if a so called sulphate resistant Portland cement is used. The binder will actually crumble and turn into a mush since CSH gel is transformed to Thaumasite (a calcium silicate carbonate sulphate hydrate; $Ca_3Si(OH)_6(CO_3)(SO_4)\cdot12H_2O$) without binding properties. Three components are required to form Thaumasite:

1. Calcium silicate (taken from the cement paste)
2. Calcium carbonate (e.g. addition of limestone filler)
3. Sulphate (usually intruded from the surroundings)

Two concepts of self-destructing concrete based on Thaumasite formation can thus be formulated:

1. Designing concrete recipes with sufficient limestone filler and high water-to-cement ratio (w/c) to make the concrete very open for diffusion of sulphates. Such concrete will be stable for storage both wet and dry until exposed for seawater (i.e. containing 2.65 g sulphate per litre). Deterioration rate will depend on w/c (i.e. increasing porosity with increasing w/c) and the concrete will probably crumple from the surface and inwards.
2. Designing concrete recipes with sufficient limestone filler and calcium sulphate in the form of either anhydrite ($CaSO_4$), hemihydrate ($CaSO_4\cdot1/2H_2O$) or gypsum ($CaSO_4\cdot2H_2O$) as additives. Anhydrite will probably be better for workability, in particularly if it is nearly "dead burnt" for delayed reactivity. Such concrete will be stable as long as it is stored dry

and will only require fresh water to start the Thaumasite formation. Furthermore, the reaction will take place uniformly throughout the concrete cross-section and an even crumbling is likely to occur.

4 LITTERATURE SURVEY

It is not so long since thaumasite became known to create problems in concrete exposed for sulphates, and "The 1st International Conference on Thaumasite in Cementitious Materials" was held at the Building Research Establishment (BRE) outside London, UK, in June 2002. The Journal Cement and Concrete Composites (Vol. 25, No. 8, December 2003) was a special issue (about 400 pages!) devoted to "Thaumasite in Cementitious Materials" with a number of papers from the first conference.

A lot of the papers concentrate on measuring techniques to determine thaumasite. When it comes to sulphate attack, it is usually from ground water etc. Only one paper deal with Thaumasite formation from seawater attack; Sibbick, T., Fenn, D. and Crammond, N.: "The Occurrence of Thaumasite as a product of Seawater Attack", Cement and Concrete Composites, Vol. 25, No. 8, December 2003, pp. 1059-1066. The bedding mortar of a recently constructed harbour wall step in South Wales had suffered severe cracking and spalling within 2 years. The reaction products formed included Thaumasite, Ettringite, Brucite and hydrated magnesium silicate. The study proves that concrete with limestone will form Thaumasite in line with the first concept of self-destructing concrete outlined in section 3, although it may take longer than one year to form.

No papers were found about deliberately forming thaumasite by mixing limestone and anhydrite together in concrete (i.e. second concept of self-destructing concrete outlined in section 3).

5 ENVIRONMENTAL ASPECTS

The main components of seawater are in decreasing order; 18,980 ppm chloride (Cl^-), 10,561 ppm sodium (Na^+), 2,650 ppm sulphate (SO_4^{2-}), 1,272 ppm magnesium (Mg^{2+}), 400 ppm calcium (Ca^{2+}), 380 ppm potassium (K^+), 140 ppm carbonate (CO_3^{2-}), 65 ppm bromide (Br^-), 13 ppm strontium (Sr^{2+}) and up to 7 ppm silica (SiO_2). Seawater is in principle saturated with respect to calcium carbonate and is essential for crustaceans, mussels etc in building protective shells. For this reason seawater has pH on the basic side (around 8).

Concrete is widely used in contact with seawater in constructions as piers, bridge pillars, oil platforms etc The experience is that it quite rapidly precipitates magnesium hydroxide in the outer pores due to the high internal pH (about 13), which is followed by growth of a calcium carbonate layer since the calcium concentration of pore water is higher than in seawater. Later mussels and alga seems to grow well on concrete surfaces, and fish is known to thrive around the concrete shafts of oil platforms.

Thaumasite, $Ca_3Si(OH)_6(CO_3)(SO_4)\cdot 12H_2O$, can be said to consist of 27.02 % calcium oxide (CaO), 9.65 % silica (SiO_2), 43.40 % water (H_2O), 7.07 % carbon dioxide (CO_2) and 12.86 % sulphur trioxide (SO_3) although it is a calcium salt of silicate, carbonate and sulphate. Thaumasite occurs naturally, and transparent crystals are for instance found in the N'Chwaning Mine, Kalahari Manganese Field, Northern Cape Province, South Africa. Another site is the Bjelke Mine near Åreskutan, Jämtland, Sweden.

Due to environmental concern, no organic admixtures were used in the concrete recipe.

Thus, the concrete recipes proposed for the anchors will not pose any threat to the marine environment since its components already exist as minerals on the seabed or as components in the seawater.

6 MATERIALS

The following materials were used in trial concrete mixing.

6.1 Cement

From SINTEFs stock

- Norcem Rapid Portland Cement (Industry cement), laboratory cement "IN5"

6.2 Limestone

Received 2003-08-21 from Spenncon Verdal

- 8 plastic bags of Verdalskalk Calcium carbonate, approximately 200 kg, Journal number A-2185

6.3 Anhydrite

Received 2003-10-21 from OUTOCOMPU in Odda, Norway

- 1 bucket of Anhydrite, approximately 80 kg, journal number A-2185

6.4 Aggregate

Received 2003-10-21 from Spenncon Verdal, journal number A-2185

- 1 Big bag of Norstone sand 0-8 mm , approximately 300 kg
- 2 Big bags of Verdalskalk, limestone 8-16 mm crushed stone, approximately 300 kg
- 2 bags of Frøseth sand 0-4 mm, approximately 50 kg

7 LABORATORY TESTS

7.1 General

Spenncon AS has produced concrete elements approximately 1,000·1,000·90 mm for EMGS since 2002 and the laboratory program was built on the recipe used at Spenncon Verdal. The same constituents were used, but due to environmental aspects the organic admixtures (i.e. plasticizers) were omitted. This will increase the water demand to make the concrete workable.

7.2 Laboratory concretes

Proposed laboratory mixes to make concrete cubes and beams are shown in Table 1. The reference concrete is the one used by Spenncon AS today. The composition of the other laboratory recipes is with increasing limestone filler content, ending up with a stoichiometric concrete composition that deteriorates the binder totally. The limestone content is increased in steps of 20% and the cement + limestone filler + anhydrite mass is kept constant to 410 kg/m^3 concrete.

The concrete density is proposed equal for all the mixes. The water/cement (w/c) ratios are increasing from 0.45 to 0.81 and thereby is the porosity increasing as well.

Table 1: Nominal concrete composition, kg/m^3

Mix no	1	2	3	4	5	6	7	8	9
% Limestone	0	20	20	40	40	60	60	80	80
Rapid cement	410	342	342	293	293	256	256	228	228
Water, free	185	185	185	185	185	185	185	185	185
Water/cement-ratio	0.45	0.54	0.54	0.63	0.63	0.72	0.72	0.81	0.81
Limestone filler	0	68	68	117	117	154	154	182	182
Anhydrite	0	0	86	0	147	0	192	0	228
Årdal 0-8 mm sand	885	885	840	885	810	885	790	885	770
Frøseth 0-3 mm sand	40	40	40	40	38	40	38	40	37
Verdalskalk 8-16 mm gravel	880	880	840	880	810	880	785	880	770
Density	2400	2400	2401	2400	2400	2400	2400	2400	2400
Cement + limestone	410	410	410	410	410	410	410	410	410

From each mix 100 mm cubes and 100·100·400 mm prisms were made. The concrete was demolded after 20 hours and placed in water at 20°C until 7 days age.

7.3 Laboratory procedures

Concrete for documentation of properties was mixed in a 60 litre forced action mixer. Each concrete was mixed in two batches to achieve a total volume of 120 litres.

The mixing was carried out according to the following procedure:

1. 1 min mixing of dry materials
2. addition of mixing water during 1 min mixing
3. addition of excess mixing water to get a slump of approximately 200 mm
4. 2 min rest
5. 2 min mixing

Fresh concrete properties for each mix were determined according to EN 12350, part 2 (slump), part 6 (density) and part 7 (air content).

Compressive strength was determined on 100 mm cubes according to EN 12390 part 3.

7.4 Curing regimes

After 7 days the specimens were stored at three temperature regimes:

1. In laboratory fresh water at 20°C
2. In sea water 5° - 9°C at Østmarkneset, later at SINTEF Fisheries and Aquaculture, Brattøra
3. In concentrated seawater (5 times artificial concentration) in laboratory at 5°C

7.5 Testing schedule

Three cubes were tested for compressive strength after demolding at 24 hours
Three cubes were tested for compressive strength after 7 days in fresh water of 20°C
The other test specimens were placed in hardening regime 2 and 3 for later testing.
The testing schedule from 1 month after mixing for each mix is shown in Table 2.
The number indicates number of cubes or prisms subjected for testing

Table 2: Testing schedule for all mixes

Testing after mixing	1 month			2 months		3 months		4 months		5 months		1 year	
Bending strength $5^{O}C$	2	3	3	3	3								
Compressive strength $5^{O}C$	3	3	3	3	3	3	3	3	3	3			
Hardening conditions	A	B	C	B	C	B	C	B	C	B	C	B	C

A - Laboratory fresh water at $20^{\circ}C$
B - Seawater, the first weeks at Østmarkneset later at Brattøra, $5\text{-}9^{\circ}C$
C - Concentrated (5 times) seawater to increase the deterioration, $5^{\circ}C$

8 TEST RESULTS

8.1 Fresh concrete

The real compositions of the 9 mixes are shown in Table 3. The workability was measured by standard slump measure according to EN 12350-2. The density and air content was measured according to EN 12350-6 and EN 12350-7, respectively.

The density and air content was measured according to EN 12350-6 and EN 12350-7, respectively.

Table 3: Real composition and fresh concrete results, (surface dry aggregates)

Concrete Mix No		1	2	3	4	5	6	7	8	9
Kg per m^3 concrete	Industry cement	400	334	277	286	212	250	170	223	143
	Calcium Carbonate	0	67	55	114	85	150	102	179	114
	Anhydrite	0	0	70	0	107	0	129	0	144
	Årdal sand 0-8 mm	856	861	866	865	870	863	863	867	862
	Frøseth sand 0-4 mm	39	39	38	38	38	38	38	38	38
	Verdalskalk 8-16 mm	856	861	861	860	865	858	858	862	857
	Free water	219	211	208	209	201	208	208	204	207
Water/binder-ratio		.55	.631	.750	.731	.950	.835	1.22	.915	1.45
Slump, batch 1, mm		195	180	200	190	190	190	210	200	210
Slump, batch 2, mm		205	190	200	200	200	190	210	200	210
Air content batch 1, %		1.2	1.3	1.2	1.2	1.4	1.3	1.0	1.3	0.9
Air content batch 2, %		1.2	1.2	1.3	1.3	1.3	1.2	0.9	1.3	0.9
Density batch 1, kg/m3		2370	2370	2375	2375	2375	2365	2365	2370	2370
Density, batch 2, kg/m3		2365	2375	2375	2370	2380	2370	2370	2375	2360

8.2 Hardened concrete (in fresh water)

Eight 100 mm cubes were cast for determination of compressive strength according to EN 12390-3 at ages 1, 7 and 28 days. The results are listed in Table 4.

Table 4: Testing results after hardening in air and fresh water

Concrete Mix No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Compressive strength, MPa after 1 day in air at 20°C	30.8	25.1	16.2	19.0	12.4	16.1	7.2	13.2	5.2
Compressive strength, MPa after 7 days in water, 20°C	42.0	37.1	27.3	33.1	22.6	27.9	15.9	23.6	13.1
Compressive strength, MPa after 28 days in water, 20°C	48.1	44.4	33.7	38.7	27.3	33.1	20.2	27.8	16.1
Compressive strength, MPa after 28 days in water, 5°C	46.5	43.2	31.5	36.9	26.6	31.6	18.9	26.7	15.1
Flexural strength, MPa after 28 days in water, 5°C	5.9	5.2	3.5	5.2	3.4	4.0	2.7	4.0	2.5

Comments: Grey shades mark results for concrete with anhydrite

8.3 Hardened concrete in sea water

The compressive and flexural strength of concrete cured in both fresh and sea water are given in Table 5. Grey shades mark results for concrete with anhydrite, – means disintegrated concrete.

Table 5: Testing results after hardening in air, fresh water and sea water

Concrete Mix No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Compressive strength, MPa after 1 day in air at 20°C	30.8	25.1	16.2	19.0	12.4	16.1	7.2	13.2	5.2
Compressive strength, MPa 7 days in fresh water, 20°C	42.0	37.1	27.3	33.1	22.6	27.9	15.9	23.6	13.1
Compressive strength, MPa 28 days in freshwater, 5°C	46.5	43.2	31.5	36.9	26.6	31.6	18.9	26.7	15.1
Compressive strength, MPa 28 days in sea water, 5°C	45.7	41.1	30.5	35.8	25.1	30.1	17.8	25.8	13.6
Compressive strength, MPa 2 months in sea water, 5°C	47.5	43.7	30.7	37.4	22.9	31.8	9.9	27.1	6.4
Compressive strength, MPa 3 months in sea water, 5°C	48.4	45.2	24.3	37.0	12.8	31.8	1.1	27.8	0.0
Compressive strength, MPa 4 months in sea water, 5°C	49.9	45.3	12.1	37.8	6.4	34.0	0.0	28.1	-
Compressive strength, MPa 5 months in sea water, 5°C	49.5	45.5	9.8	37.7	1.0	33.1	-	27.5	-
Compressive strength, MPa 12 months in sea water, 5°C	53.1	47.3	0.0	39.4	0.0	32.1	-	26.2	-
Flexural strength, MPa 28 days in freshwater, 5°C	5.9	5.2	3.5	5.2	3.4	4.0	2.7	4.0	2.5
Flexural strength, MPa 28 days in sea water, 5°C	6.5	5.6	3.6	5.1	3.5	4.6	2.7	3.9	2.3
Flexural strength, MPa 2 months in sea water, 5°C	6.3	5.8	3.7	5.5	3.1	5.0	1.8	4.2	1.2

8.4 Hardened concrete in concentrated sea water (salt water)

Compressive strength of concrete stored in concentrated (5x) sea water is given in Table 6.

Table 6: Testing results after hardening in air, fresh water and salt water

Concrete Mix No	1	2	3	4	5	6	7	8	9
Compressive strength, MPa after 1 day in air at 20°C	30.8	25.1	16.2	19.0	12.4	16.1	7.2	13.2	5.2
Compressive strength, MPa 7 days in fresh water, 20°C	42.0	37.1	27.3	33.1	22.6	27.9	15.9	23.6	13.1
Compressive strength, MPa 28 days in fresh water, 5°C	46.5	43.2	31.5	36.9	26.6	31.6	18.9	26.7	15.1
Compressive strength, MPa 28 days in salt water, 5°C	44.7	41.7	29.2	33.9	23.6	30.1	15.5	25.1	13.2
Compressive strength, MPa 2 months in salt water, 5°C	47.2	42.5	20.7	35.5	21.8	30.1	12.7	25.5	9.3
Compressive strength, MPa 3 months in salt water, 5°C	45.9	42.5	17.6	34.9	10.8	28.1	4.1	26.4	2.0
Compressive strength, MPa 4 months in salt water, 5°C	44.3	41.4	14.4	34.8	7.4	26.0	0.0	25.8	0.0
Compressive strength, MPa 12 months in salt water, 5°C	48.4	41.8	0.0	33.8	0.0	26.3	-	22.8	-
Flexural strength, MPa 28 days in freshwater, 5°C	5.9	5.2	3.5	5.2	3.4	4.0	2.7	4.0	2.5
Flexural strength, MPa 28 days in c. salt water, 5°C	6.5	6.0	3.4	5.1	3.2	4.7	2.7	4.0	2.3
Flexural strength, MPa 2 months in salt water, 5°C	5.8	6.2	3.6	5.3	3.0	5.0	2.1	4.7	1.5

Comments: Grey shades mark results for concrete with anhydrite

9 DISCUSSION

9.1 Concrete cured in fresh water

The development of compressive strength after 28 days curing versus water/cement ratio is shown in Fig. 1 and compared with results from Norcem. The strength of concrete with limestone filler, as well as limestone filler and anhydrite, is close to the reference mixes.

9.2 Concrete cured in sea water

All the concrete cubes (and prisms) were stored their moulds in laboratory conditions the first day and thereafter hardened in fresh water up to seven days. Then the prisms were placed in seawater (5°C to 9°C) and tested 1, 2, 3, 4, 5 and 12 months after casting. Fig. 2 shows the results with limestone filler only, while Fig. 3 depicts the result with limestone filler and anhydrite in stoichiometric ratio with respect to thaumasite formation.

Addition of limestone as the only additive has not yet (within the test period) given any significant deterioration, even for the most permeable and porous concrete.

The addition of both limestone filler and anhydrite to the concrete has caused increasing disintegration with increasing amount of additives. Concrete specimens with 60 and 80 % limestone filler of cement weight were totally destroyed after 3 months.

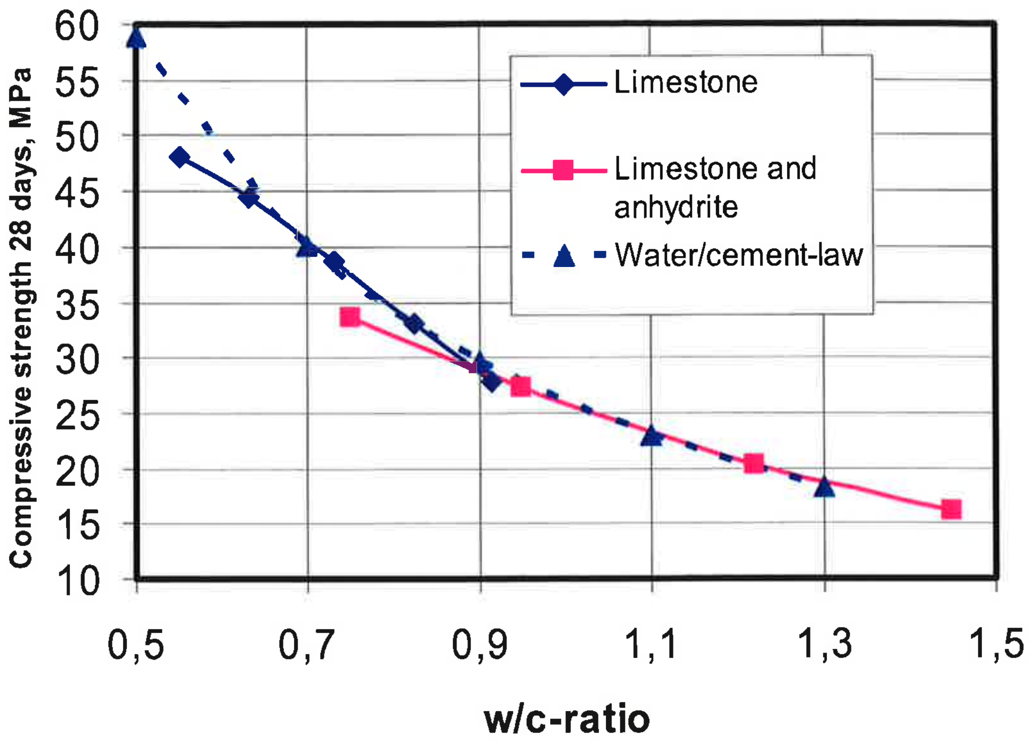

Fig. 1 Compressive strength at 28 days versus water-to-cement ratio for concrete.

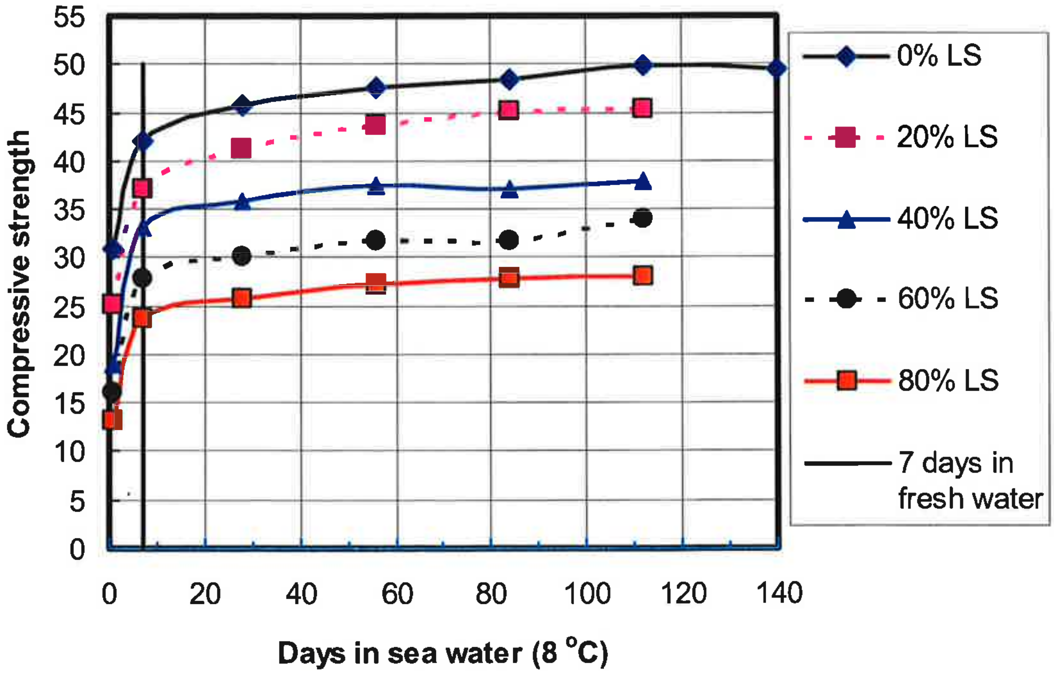

Fig. 2 Compressive strength evolution for concrete as a function of time and limestone (LS) addition.

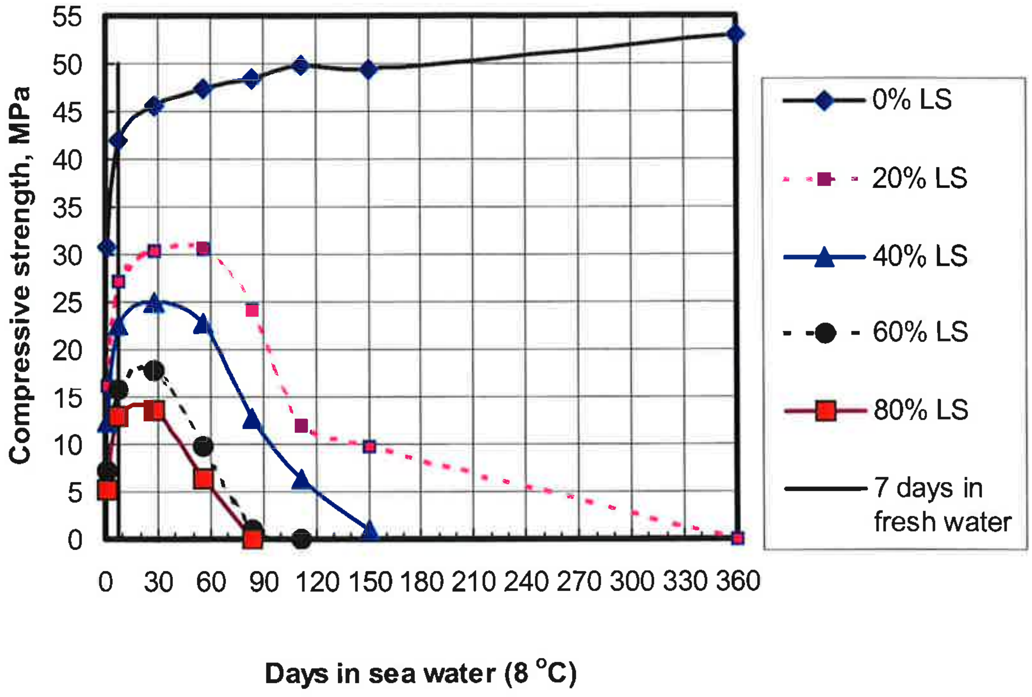

Fig. 3 Compressive strength evolution for concrete as a function of time and addition of limestone (LS)/anhydrite (ratio stoichiometric with respect to thaumasite).

9.3 Deteriorating test the first month

Deterioration before 1 month had to be avoided since this is within the usage period, and the concrete was specially monitored during this period. The ratio between 28 days (1 month) strength after storage in sea and fresh water is given in Table 7 for the different concrete mixes.

Table 7: Strength development after hardening in freshwater and sea water

Concrete Mix No	1	2	3	4	5	6	7	8	9
Compressive strength, MPa 7 days in fresh water, 20°C	42.0	37.1	**27.3**	33.1	**22.6**	27.9	**15.9**	23.6	**13.1**
Compressive strength, MPa 28 days in freshwater, 5°C	46.5	43.2	**31.5**	36.9	**26.6**	31.6	**18.9**	26.7	**15.1**
Compressive strength, MPa 28 days in sea water, 5°C	45.7	41.1	**30.5**	35.8	**25.1**	30.1	**17.8**	25.8	**13.6**
Strength sea water 28 days/ Strength fresh water 28 days	0.98	0.95	**0.97**	0.97	**0.94**	0.95	**0.94**	0.97	**0.90**
Flexural strength, MPa 28 days in freshwater, 5°C	5.9	5.2	**3.5**	5.2	**3.4**	4.0	**2.7**	4.0	**2.5**
Flexural strength, MPa 28 days in sea water, 5°C	6.5	5.6	**3.6**	5.1	**3.5**	4.6	**2.7**	3.9	**2.3**
Strength sea water 28 days/ Strength fresh water 28 days	1.10	1.08	**1.03**	0.98	**1.03**	1.15	**1.00**	0.98	**0.92**

Comments: Grey shades marks results for concrete with anhydrite

Compressive strength deterioration is less than 10% for all mixes during the three first weeks of exposure to sea water, which make them suitable as anchors for the seabed logging period.

The flexural strength was higher after three weeks exposure in sea water, except for the highest amount of limestone filler and anhydrite.

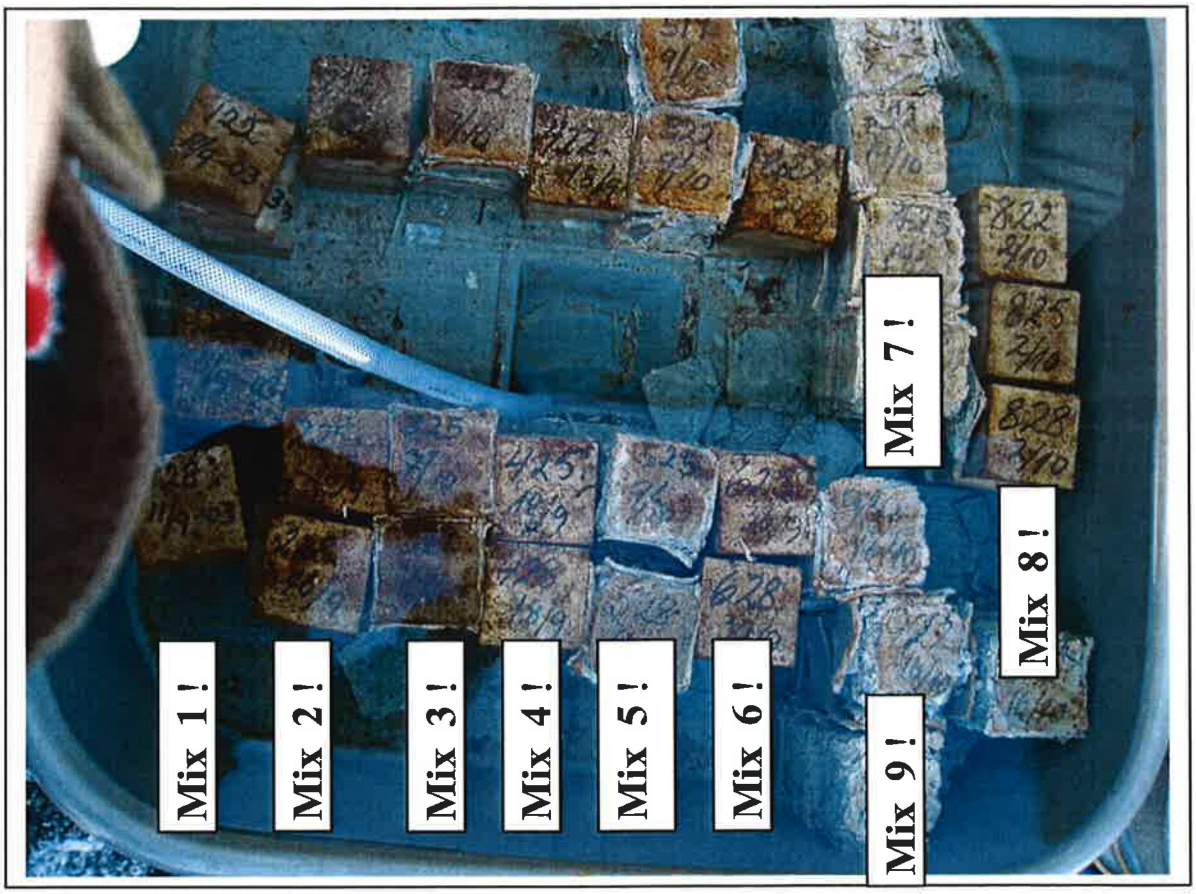

Fig. 4 Concrete specimens after about 4 months in natural sea water.

The appearance of concrete specimens after 4 months in natural seawater is shown in Fig. 4. Mixes 5, 7 and 9 deteriorate from the surface and mix 9 is most affected. The surfaces are also covered with a brown slime. This can either be due to iron hydroxide precipitate originating from possible corroding tube transporting seawater, or the growth of brown algae naturally occurring in seawater.

The appearance of mix 9 specimens after 3 and 4 months are depicted in Figs. 5 and 6, respectively, while the status of all mixes after 5 months in sea water is shown in Fig. 7 (to be compared with Fig. 4 for specimens after 4 months). Note that concrete from mix 7 and 9 is completely disintegrated after 5 months.

Fig. 5 Mix 9 after 3 months in sea water.

Fig. 6 Mix 9 after 4 months in sea water

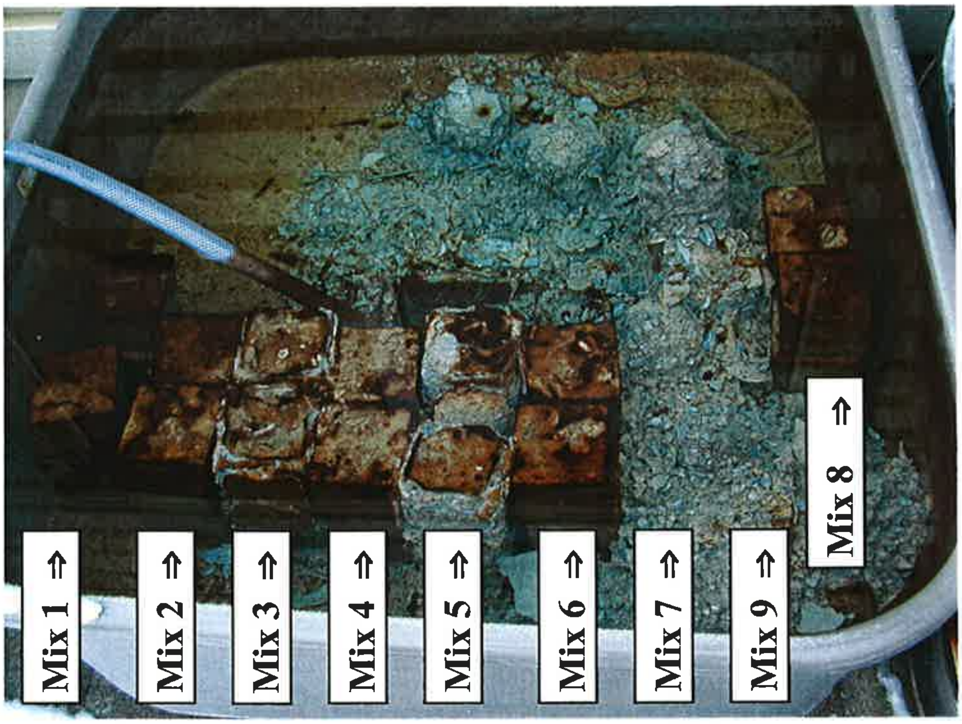

Fig. 7 Deterioration of concrete specimens as of February 12th, 2004, ≈ 5 months after casting

9.4 Concrete cured in concentrated sea water

There was only a small difference in deterioration between sea water and concentrated (5x) sea water for mixes with anhydrite. Since the specimen without anhydrite in natural seawater did not deteriorate, it is difficult to say whether the concentrated sea water increases the deterioration rate or not, but the compressive strength was somewhat lower after storage in concentrated sea water as seen by comparing results in Table 5 and 6.

10 EFFECT OF STORING PLATES

Concrete anchor elements are normally used before half a year after produced. Using concrete mix no 5 (Table 3 page 7), totally 10 plates with dimensions 900·900·90 mm were produced at

Spenncon Verdal, 3rd March, 2004. The first three weeks the plates were stored in the factory and two plates were tested in bending at SINTEF. After that the 8 remaining plates were stored outside the factory (4 plates) and inside the factory (4 plates). Two parallel plates from outside and inside storing were tested 4 and 6 months after casting. The results are given in Table 8.

Table 8: Strength development of plates inside and outside Spenncon factory, kN and (MPa)

Storing conditions / Hardening time	Inside factory	Outside factory
3 weeks	12.5 (2.06)	-
4 months	14.4 (2.38)	16.7 (2.75)
6 months	18.9 (3.12)	18.6 (3.07)

The weight of the plate will give an additional force of 0.8 kN.

After 6 months there was no sign of deterioration of the plates, stored inside as well as outside.

11 CONCLUSIONS

Including limestone filler (i.e. calcium carbonate) in the concrete recipe did not deteriorate hardened concrete within 6 months after submersion in seawater.

To accelerate deterioration, tests were also performed by adding calcium carbonate and anhydrite in a stoichiometric ratio with respect to thaumasite that would deteriorate the binder totally. These specimens disintegrated in contrast to the specimen without anhydrite.

Increasing the amount of inorganic additives decreased the 7 and 28 days compressive strength for concrete hardened in fresh water.

A recommended concrete composition with 40 % limestone filler and a stoichiometric ratio of anhydrite with respect to thaumasite was found to disintegrate in seawater after 4 months, and was tested further. Two compositions of the recommended concrete are:

Ingredients in kg/m^3	Producer	Recipe 1	Recipe 2
Rapid Portland Cement	Norcem	210	210
Free water		195	195
Limestone filler	Verdal Kalkverk	85	85
Anhydrite	Outocompu, Odda	110	110
Sand 0-8 mm	Norstone, Årdal	880	920
Sand 0-4 mm	Frøseth, local deposite	40	0
Crushed stone 8-16 mm	Verdal Kalkverk	880	880

After 6 months there was no sign of deterioration of concrete plates with the recommended recipe, stored inside as well as outside.

The concrete contains no ingredients harmful to the marine environment it is meant to serve in. All ingredients are found in natural gravel, limestone and/or seawater. The concrete does not contain any organic admixtures.

Appendix 2

DNV Letter of Verification

EMGS ASA,
Pb. 1878 Lade
7440 Trondheim
Norway
Att: Audun Sødal

DET NORSKE VERITAS AS
P.O BOX 300
1363 HØVIK
NORWAY

TEL: 00 47 67 57 99 00

Date: 2013-09-12

Your ref: Our ref: 18D24J0-3_1-8G9242_CT

Verification of testing for the EMGS ASA, Self-disintegrating anchors for wide range sea temperatures.

To whom it may concern

DNV is pleased to inform the reader that EMGS ASA have, as of 27th June 2013, entered into agreement with DNV for the Verification of Testing at SINTEF of a new anchor mix design. It is intended that the new anchor mix design will allow the break down over time in a sea water environment with wide ranging temperatures (to be defined post development stage).

DNV's scope of work as part of the verification scheme consists of:

- Review of laboratory test procedure
- Witness of testing at SINTEF test laboratory
- Evaluation of test reports from SINTEF laboratory
- Issuance of report & Letter/Statement

This letter is issued at request of EMGS ASA for information purposes only and does not constitute in any way an assurance of a positive outcome of the testing program. Date for completion of the testing program has not been decided yet.

Yours sincerely
For Det Norske Veritas AS

[redacted]

[redacted]

Head of Section
Offshore Concrete Structures