MID-ATLANTIC POWER PATHWAY &

THE CHESAPEAKE BAY

A PRELIMINARY REVIEW OF THE IMPACT OF PLACING PORTIONS OF AN EXTRA-HIGH VOLTAGE TRANSMISSION LINE BENEATH THE CHESAPEAKE BAY & OTHER WATERS

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On Behalf Of

DORCHESTER CITIZENS FOR SAFE ENERGY

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SUMMARY

The Mid-Atlantic Power Pathway (MAPP) is a proposed 152-mile high voltage direct current (HVDC) transmission line project. The transmission line would be buried beneath 16 miles of the Chesapeake Bay and 23 miles of the Choptank River.

MAPP would be the first transmission line to cross the Chesapeake Bay. The precedent set by this first project could lead to other utilities crossing the Bay. It is possible that the 39 mile MAPP route would become the corridor of choice for future utilities. Before this precedent is set a panel of leading Bay scientists should be convened to determine if a transmission line can be cross the Bay without causing excessive harm and, if it can, then what is the best route.

The best example of the type of review required is *Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of off shore renewable energy.*[1] More than a thousand scientific studies, 400 of which were peer reviewed, formed the basis of the Greening Blue Energy report.

This document is a far cry from Greening Blue Energy. It was compiled by Dorchester Citizens for Safe Energy (DCSE) as an initial attempt to determine if there was valid reason to be concerned about running MAPP beneath the Chesapeake Bay and Choptank River. Following is a summary of potential impacts based upon the very limited number of studies reviewed for this document.

It could take up to 30 months or even longer for the 85 acres of Bay and River bottom to recover from the initial installation. Periodic maintenance may cause additional disturbance. Bottom-dwelling (benthic) organism diversity and numbers would be reduced by the installation with recovery requiring up to 30 months or even longer. The electromagnetic field emitted by the cables could alter the behavior of some fish species out to a distance of about 1,000 feet affecting an area of about 9,500 acres.

The cables may heat to a temperature of 158°F. It is possible heating may induce interstitial currents in adjoining sediments that increase the release of phosphorus and other pollutants from bottom sediments.

Boating could be affected by altering compass readings or through the possibility of anchors snagging a cable, particularly when anchors drag during storms through the soft sediments in deeper waters. While the cables will initially be buried to a depth of six feet the cables could be exposed during storm periods, which happened two-years after the Cross Sound Cable was buried beneath Long Island Sound.

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[1] *Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of off shore renewable energy*, is a publication of the International Union for Conservation of Nature and is available online at: cmsdata.iucn.org/downloads/2010_014.pdf

These findings should be considered tentative until verified by the more comprehensive analysis suggested above. A reference to the relevant studies is provided at the end of each finding.

INTRODUCTION

Dorchester Citizens for Safe Energy (DCSE) is an alliance of property owners and others concerned about a proposed extra-high voltage transmission line. This project, known as the Mid-Atlantic Power Pathway (MAPP), consists of a 152-mile, 500- to 640-kilovolt (kV) transmission line carrying up to 2,100 megawatts (MW) of electricity from Possum Point, Virginia to Indian River, Delaware *(see Figure 1)*. The portion of concern to DCSE is that proposed to originate north of the Calvert Cliffs nuclear plant, cross beneath 16 miles of the Chesapeake Bay and 23 miles of the Choptank River, cross northern Dorchester County to Vienna.

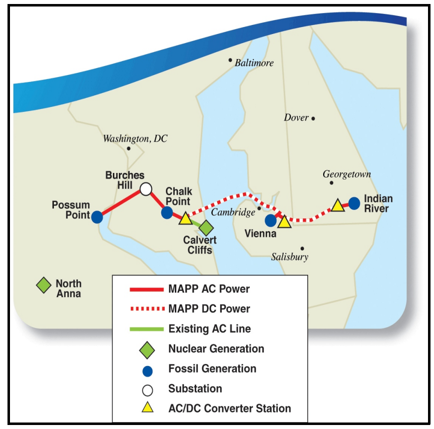

Figure 1: MAPP Route

DCSE is not opposed to the MAPP project per se. We do insist that all reasonable alternatives be considered for maintaining reliable, affordable electric service and that the benefits of each be balanced against the negative effects.

A precedent could also be set leading to similar projects in the future along this same Bay-Choptank River route. There are clear, viable alternatives to the proposed project that would maintain safe, affordable electricity yet negate would could be substantial environmental impacts. However, we are concerned that reviewing agencies will lack the information needed to compare the pros and cons of the Chesapeake-Choptank cable option with these alternatives. This is why Dorchester Citizens for Safe Energy and a coalition of national, statewide and local groups are calling for a thorough review by an independent panel of leading Bay scientists. We view two documents as models for the analysis we hope the Bay scientists will produce:

- Long Island Sound Symposium: A Study of Benthic Habitats, available online at: http://www.ctenergy.org/pdf/LIS.pdf; and
- Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of off shore renewable energy, available at: cmsdata.iucn.org/downloads/2010_014.pdf

The proposed transmission line route is shown in Figure 2. With the exception of where the cables come ashore in Goose Creek, just south of Secretary, the transmission line will be at least 1,000 feet from the Choptank River shoreline and buried at a depth greater than 20 feet. Prior to laying the cables grapnel anchors will be dragged along the 39-mile route to remove obstructions buried to a depth of two- to three-feet beneath the Bay and River bed. Along this 39-mile route two 500 kilovolt Direct Current (DC) circuits would be buried in separate trenches

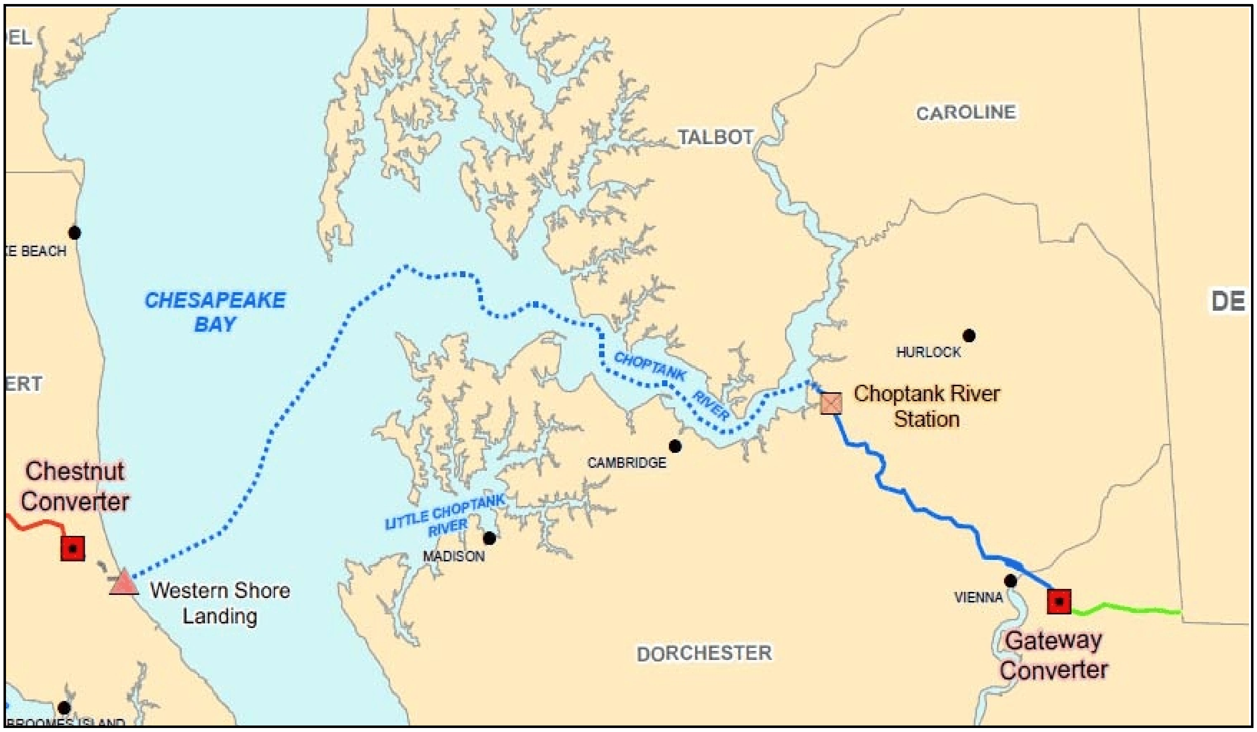

Figure 2: Submerged & North Dorchester Route

a minimum of six-feet beneath the Bay and River bed. The trenches would by excavated with a jet plow. Each trench would be two- to three-feet wide and a minimum of 80 feet apart. A three-foot wide depression would also be created along both sides of each trench as jet-plow skids are dragged along. Each trench would hold one DC circuit consists of two 5.25-inch cables. Initial installation would disturb a nine-foot width of Bay and River bottom for each circuit or a total of 18-feet of bottom disturbance. Therefore, initial installation would directly impact 85 acres of Chesapeake Bay and Choptank River bottom.[2]

POTENTIAL IMPACTS

Several of the studies referenced below examined the before and "after" effects of two submerged HVDC transmission lines. The first line is the Cross Sound Cable project where HVDC cables were buried beneath 23 miles of Long Island Sound. The second was the Neptune Regional Transmission System (RTS) line which runs 51 miles beneath the Raritan River in New Jersey out into the Atlantic Ocean to come ashore on Long Island.

There are a number of important differences between the MAPP project and the Cross Sound Cable and Neptune RTS. MAPP will have a transfer capacity of 2100 megawatts (MW) of electricity whereas the Cross Sound and Neptune projects have a capacity of 330 and 660

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[2] The description of how the cables would be laid comes from *Environmental Review Document Chalk Point to Maryland/Delaware State Line*, prepared by Entrix and dated November 2010. This document is available on the Maryland Public Service Commission website under Case No. 9179.

MW, respectively. The difference in transfer capacity could cause greater electromagnetic field or thermal effects. The Cross Sound and Neptune cables were laid in marine environments whereas the Chesapeake is an estuarine ecosystem. Sediments encountered in the Cross Sound and Neptune projects are generally coarser (more sandy) then those in the Bay and Choptank. This is due in part to the fact that the Cross Sound and Neptune projects are in higher energy areas. Of course there are also substantial differences in species composition, water quality characteristics, and other important factors.

Following is a summary of the preliminary findings from this initial review.

Bottom Disturbance

The depression created through the installation of the Cross-Sound Cable was up to 2.5-feet deep and 25-feet in width 30 months following installation in three of four study areas. The depression was no longer evident in the fourth study area when the last survey was made in 2005. Reference: Ocean Surveys 2005.

Generally, the disturbance to bottom sediments caused by activities similar to those of burying a cable, such as fishing trawls or clam dredging, show that recovery is rapid in shallow (<30 feet) areas subject to natural disturbances (storm generated waves, tidal currents, etc.) particularly where the bottom is sandy. Recovery is much slower in deeper (>40 feet), muddy substrates. In shallow, sandy areas recovery can occur in 1- to 13-days. In deeper, muddy substrate recovery may take more then 60 days, possibly years. References: Constantino et al. 2008; Falcao et al. 2003; Galagan et al. 2005; Johnson 2002; Jones 1992; Kaiser et al. 1996; and LIS 2004.

The Chesapeake Bay is up to 90 feet deep between Calvert Cliffs and Taylors Island.[3] About half the Bay bottom in this area is mud (silty-clay) with sand in the shallower areas along the shores.[4] Therefore, the impact to the 85 acres of Bay and River bottom potentially affected by the MAPP project could be substantial and of long duration. Periodic maintenance may cause additional disturbance.

Horizontal drilling can currently place up to 7,200 feet of cable with little disturbance to the surface of bottom sediments (LIS 2004). However, the Bay is nearly five-times this width between Calvert Cliffs and Taylors Island.

Benthic Community

The bottom-dwelling (benthic) community in the vicinity of the Cross-Sound Cable had not fully recovered by the time the 30-month post-installation study was completed. However, the authors

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[3] Depth of the Bay between the Calvert Cliffs plant and Taylors Island was obtained from Chart 6 in the *ADC Chesapeake Bay Chartbook*.

[4] Bay bottom characteristics are based upon the sediment distribution map posted on the Maryland Geological Survey website at: http://www.mgs.md.gov/coastal/pub/baysedist.pdf

cited seasonal variations in benthic communities as making data interpretation difficult. It appears that prior to cable installation the benthic community was sampled during only one season - spring (May 2002). Post-installation sampling was conducted during: October and November 2002, May 2003, November-December 2003, and March 2005. Reference: Ocean Surveys 2005.

In Neptune RTS surf clam populations along the route were compared before and after installation. No significant differences were found at 15-months following installation. Reference: HDR 2008.

As noted below in the section on thermal impact, the HVDC cables used in the Cross-Sound project are designed to withstand a temperature of up to 158°F and were predicted to cause up to a 0.2°F temperature increase in the seabed surface if buried at a depth of six feet.

Finfish

In the Neptune RTS studies, similar finfish species richness was observed during the fisheries surveys, with 18 species collected during the pre-installation survey and 15 collected during the post-installation survey. Reference: HDR/LMS 2007**.**

A review of the scientific literature regarding the effects of transmission cable magnetic fields cited several studies noting localized interference with fish behavior Reference: Ohman et al. 2007.

The behavior of some sharks, rays and other elasmobranch species is altered in the vicinity of cables carrying electricity from offshore wind turbines. Specifically, some individuals of some species tend to congregate in the vicinity when cables are carrying electricity. The effect occurs out to a distance of 295 meters (968 feet) from the cables. Reference: Gill et al. 2009.

Boater Safety

One of the public safety issues associated with submerged cables is the danger of an anchor striking the cable, but newer cables are designed in a way which creates very little danger. Reference: LIS 2004. With respect to the Cross-Sound Cable the U.S. Army Corps of Engineers recommended a minimum burial depth of six feet to prevent anchor damage.[5]

The effect of the Cross-Sound Cable on compasses and other ship navigation systems was studied, with no adverse effects noted. Reference: Ocean Surveys 2005.

A mono-polar HVDC cable located between Sweden and Finland did generate a magnetic field strong enough to influence ship compasses. However, the magnetic field from bi-polar HVDC cables did not extend more then 25 meters (82 feet). Reference: Ohman et al. 2007.

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[5] Connecticut Siting Council Findings of Fact #55, Docket No. 208 January 3, 2002.

Cable Exposure
A portion of the Cross-Sound Cable became exposed two years following initial installation and was reburied. Reference: Ocean Surveys 2005. Electricity flow through the cable was turned off during the two months required to rebury the cable.

In areas subject to sand-wave migration a cable may be exposed within 6- to 18-years following installation if no mitigation measures area taken. Reference: Galagan et al. 2005.

Thermal Impact
The Cross-Sound Cable was designed to operate at up to 158°F and would cause no more then a 0.2°F temperature increase in the seabed surface if buried at a depth of six feet.[6] Modeling by the Connecticut Siting Council indicated that the Cross-Sound Cable would not significantly raise the temperature of waters overlying the cable.

It appears that sufficient heat is not transferred from a submerged cable to the sediment-water interface to cause an adverse effect, however this preliminary review did not uncover studies which examined the actual thermal impact of a submerged cable. References: LIS 2004.

Release of Transmission Line Cooling Fluids
Oil was used in older cables as a cooling agent. More recent submerged cables do not use a cooling fluid, but this may not be true for all future cable installations. References: LIS 2004.

Electromagnetic Field (EMF)
A review of the scientific literature regarding the effects of transmission cable magnetic fields cited several studies noting localized interference with fish behavior. Reference: Ohman et al. 2007.

No anomalous readings were detected during monitoring of the Cross-Sound Cable. Reference: Ocean Surveys 2005.

It does not appear that an electromagnetic field is produced outside of the shielded conductors of a submerged electric cable. Reference: LIS 2004.

The behavior of some sharks, rays and other elasmobranch species is altered in the vicinity of cables carrying electricity from offshore wind turbines. Specifically, some individuals of some species tend to congregate in the vicinity when cables are carrying electricity. The effect occurs out to a distance of 295 meters (968 feet) from the cables. Reference: Gill et al. 2009.

RELEVANT STUDIES - ABSTRACTS & EXECUTIVE SUMMARIES
There are relatively few studies where the effects of a modern, submerged electric cable were examined. However, a number of studies do exist where the impact of similar activities (clam

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[6] Connecticut Siting Council Findings of Fact #26 and 27, Docket No. 208 January 3, 2002.

dredging, trawling, etc.) were evaluated. Following is the abstract or executive summary from relevant studies.

Constantino et al. 2009

Constantino, R., M.B. Gaspara, J. Tata-Regalaa, S. Carvalhoa, J. Cúrdiaa, T. Dragoa, R. Tabordab and C.C. Monteiro, 2009. Clam dredging effects and subsequent recovery of benthic communities at different depth ranges. Marine Environmental Research (2009) 67(1).

ABSTRACT

This study aimed to assess the potential effects of clam dredging and the subsequent recovery of the benthic environment. Two experimental areas located at 6 and 18 m depth were established in order to analyze whether impacts and recovery of benthic environment are depth-related. Study areas were located within an area closed to dredging and two different plots were established at both depths. One of the plots was subjected to intense clam dredge-fishing, while the other was undisturbed and therefore used as control. Sampling followed a BACI design, with samples for macrobenthic, meiobenthic and sediment particle size analysis being taken by SCUBA divers from both areas before and after fishing stress. For both depths, impacts on the benthic environment were very low resulting in high recovery rates. Nevertheless, at shallower depths communities demonstrated a faster recovery. It was shown that depending on the faunal component used as a bioindicator, different results can be observed. Generally deposit-feeding organisms with scales or chitinous plates and vermiform shape (mainly crustaceans, polychaetes and ophiuroids), without external protection, were the most affected by dredging, while some polychaetes without external protection and with a carnivorous feeding mode seemed to be enhanced by fishing. The low level of perturbations induced by the dredging activities was comparable to the impact of surface waves on the bottom, as experiments were undertaken in wave-dominated environments. The coexistence of storm events during the study period proved to have similar or even more deleterious effects on the benthic environment. It appears that communities from hydrodynamic fishing grounds that are well adapted to natural physical stress are not highly affected by dredging.

Falcao et al. 2003

Falcao, M, M.B. Gaspara, M. Caetanob, M.N. Santosa, C. Valeb, 2003. Short-term environmental impact of clam dredging in coastal waters (south of Portugal): chemical disturbance and subsequent recovery of seabed. Marine Environmental Research 56 (2003) 649-664.

ABSTRACT

The physical and chemical changes in sediment and near bottom water caused by clam dredging were examined during July and September 1999, at two locations Vilamoura (VL) and Armona (AR), south coast of Portugal. Sediment cores and near bottom water were collected simultaneously before dredging (control samples) and within short time intervals (min–h) after dredging. After dredging operations, microphytobenthos coming from the path were accumulated in the re-worked sediment (ridge). Chlorophyll a in superficial sediment

increased from 1.2 µg g-1 before dredging to 1.7 µg g-1 after dredging and these higher values remained for a few hours. However, the expected increase of chlorophyll a in near bottom water due to re-suspension was not observed. After sediment disturbance an instantaneous sorption of phosphorus onto iron oxides occurred in the upper sediment layers (from 2 to 3 µmol g-1 before dredging to 4–5 µmol g-1 after dredging). A microcosm experiment showed that after sediment disturbance HPO42- dissolved in pore water decreased from 40 to 10 µM being simultaneously sorbed onto iron oxides formed in the top layer of sediment. The ammonium, nitrates, organic nitrogen, phosphate and silicate dissolved in pore water decreased immediately after dredging activity and simultaneously an increase in near bottom water was sporadically observed. Generally, the re-establishment of seabed was reached within a short time (min–h), at both stations (VL and AR).

Galagan et al. 2005

Galagan, C., T. Isaki, and C. Swanson, 2005. Estimates of seabed scar recovery from jet plow cable burial operations and possible cable exposure on Horseshoe Shoal from sand wave migration. A Report by the Connecticut Academy of Science and Engineering for the Connecticut Energy Advisory Board. Applied Science Associates, Inc., 70 Dean Knauss Drive, Narragansett, RI 02883. Available online at: www.mms.gov/offshore/PDFs/CWFiles/06.pdf

EXECUTIVE SUMMARY

Jetting technology is planned for use to bury the electrical cables associated with the Cape Wind Energy Project. During the jetting process some sediment is injected into the water column and a portion is transported by the current away from the trench. This loss can result in a depression or scar on the seabed. Portions of the proposed cable routes occur in areas of large migrating bed forms, creating the potential for cable exposure as sand waves move past buried cables. This report presents the results of an analysis of existing data along with a discussion of relevant work at other similar sites to answer the questions concerning cable burial activities in Nantucket Sound.

Seabed Scar Recovery

It is estimated that seabed scars of 1.8 m (6 ft) wide and from 0.23 to 0.52 m (0.75 to 1.7 ft) deep will result from cable burial activities. DeAltdris et al. present observations on seabed scars resulting from fishing gear that are similar in dimension to those estimated to occur from cable burial from hydraulic jetting. For these observations, seabed scars 15 cm (0.5 ft) deep and 1.2m (3.9 ft) long were created on three separate occasions and observed daily. Scars in a sandy area lasted between 1 and 4 days at a deeper muddy site, scars were observed to be unchanged for a period of 60 days.

The rate at which seabed scars recover is a function of the sediment volume flux through the scarred area. Sediment transport rates for Horseshoe Shoal of up to 3.0 m^3/day per meter (32 ft^3/day per foot) of seabed (USACE, 2004) provide the upper bound for sediment flux within the proposed wind farm area. The Shoal experiences some of the highest transport rates in Nantucket Sound and the rates decrease moving away from the shoal into deeper water.

The methodology of van Rijn (1993) was used to calculate bedload sediment flux at core locations along the proposed 1 15kV cable outside the Horseshoe Shoal area. Bedload transport rates at the core locations range from 0.017 to 2.3 m^3/day per meter (0.18 to 25 ft^3/day per foot) of seabed. Together the flux rates from Horseshoe Shoal (USACE, 2004) and the rates calculated using the method of van Rijn represent the range of sediment flux throughout Nantucket Sound.

Based on these transport rates, recovery rates for jetting scars along the cable route are estimated to be between 0.2 and 38 days. Recovery of jetting scars on Horseshoe Shoal is anticipated to occur within a few days.

Areas of low wave and tidal current energy and a predominately mud bottom such as Lewis Bay are typically dominated by suspended sediment load. In these areas it is likely that seabed scar\from cable burial will last months or until a major storm (hurricane or major nor'easter) occurs. Deposition rate\ in estuaries in southern New England typically range from 0.2 - 2.0 cm/yr (0.079 - 0.79 in/yr) (John King, personal communication).

Increased scour at the trench site due to the presence of the burial scar is unlikely. The maximum cable burial scar depth is 52 cm (1.7 ft) and flow across the scar will actually decrease slightly due to the increased depth, decreasing sediment transport potential.

Cable/Sand Wave Interaction

Morelissen et al. report that pipelines in the North Sea have been exposed by migrating sand waves, in some cases resulting in free pipeline spans where scour removes sediment from beneath the pipeline. Results from combined modeling and field data show that sand waves in the North Sea study area of Morelissen et al. migrate on the order of 10 meters/year (33 feet/year), a rate that varies with variation in sand wave amplitude. Moore, et al. (2004) determined migration rates of giant sand waves (amplitudes up to 17 m (56ft)) in eastern Long Island Sound of 2.5 m/yr (8.2ft/yr). Sand waves on Horseshoe Shoal have amplitudes of up to 3.7 m (12 ft) and wavelengths of up to 60 m (200 ft) (USACE. 2004).

More than 42 km (26 miles) of the total proposed 33kV cable route occurs in areas of active sand wave migration on Horseshoe Shoal. Assuming bedform migration rates of 1-3 m/yr (3.3-9.8 ft/yr) and cable burial depths of 1.8 m (6 ft) it is possible that cable exposure could occur within 6-18 years after burial if no mitigation measures are employed.

Johnson 2002

Johnson, K., 2002. A Review of National and International Literature on the Effects of Fishing on Benthic Habitats. Office of Habitat Conservation, National Marine Fisheries Service, NOAA, 1315 East-West Highway, Silver Spring, MD 20910. Available online at: http://www.nmfs.noaa.gov/habitat/habitatprotection/pdf/efh/literature/KJohnson.pdf

EXECUTIVE SUMMARY ***excerpt***

II. Scope of Gear Effects

Types of potential effects on habitat from fishing fall into specific categories, including alteration of physical structure, sediment suspension, chemical modifications, benthic community changes, and ecosystem changes. These general effects are discussed below.

A. Alteration of Physical Structure

Physical effects of fishing gear can include scraping, ploughing, burial of mounds, smoothing of sand ripples, removal of stones or dragging and turning of boulders, removal of taxa that produce structure, and removal or shredding of submerged aquatic vegetation (Fonseca et al.1984, Messieh et al. 1991, Black and Parry 1994, Gordon et al. 1998, Kaiser et al. 1998, Lindeboom and de Groot 1998, Schwinghamer et al. 1998, Auster and Langton 1999, Kaiser et al. 1999, Ardizzone et al. 2000). These physical alterations reduce the heterogeneity of the sediment surface, alter the texture of the sediments, and reduce the structure available to biota as habitat. As mobile gear is dragged across the seafloor, parts of some gears can penetrate up to 5-30 cm into the substrate under usual fishing conditions, and likely to greater depths under unusual conditions (Drew and Larsen 1994). This action can leave tracks or even trenches in the seafloor, depending on the sediment type. It is unknown whether or to what extent these manmade features might compensate for the sediment smoothing actions of the gear.

B. Sediment Suspension

Resuspension of sediments occurs as fishing gear is dragged along the seafloor. Effects of sediment suspension can include reduction of light available for photosynthetic organisms, burial of benthic biota, smothering of spawning areas, and negative effects on feeding and metabolic rates of organisms. If resuspension occurs over a large enough area it can actually cause large scale redistribution of sediments (Messieh et al. 1991, Black and Parry 1994). Resuspension may also have important implications for nutrient budgets due to burial of fresh organic matter and exposure of deep anaerobic sediment, upward flux of dissolved nutrients in porewater, and change in metabolism of benthic infauna (Mayer et al. 1991, Pilskaln et al. 1998). Effects of sediment resuspension are site-specific and depend on sediment grain size and type, water depth, hydrological conditions, faunal influences, and water mass size and configuration (Hayes et al. 1984, LaSalle 1990, Barnes et al. 1991, Coen 1995). Effects are likely more significant in waters that are normally clear compared with areas that are already highly perturbed by physical forces (Kaiser 2000). Schoellhamer (1996) concluded that resuspension by natural mechanisms in a shallow estuary in west-central Florida was less frequent and of smaller magnitude than anthropogenic mechanisms (e.g., fishing) and that sediments disturbed by fishing were more susceptible to resuspension by tidal currents. Modeling by Churchill (1989) concluded that resuspension by trawling is the primary source of suspended sediment over the outer continental shelf, where storm-related stresses are weak. In the Kattegat Sea, Sweden, sandy sediments above the halocline were more affected by wind- induced impacts than by fishing effort, but mud sediments below the halocline experie nced an increase in the frequency of disturbance by 90% in the spring and summer and by 75-85% in the autumn and winter due to fishing (Floderus and Pihl 1990). Thus, even when recovery times are fast, persistent disturbance by fishing could lead to cumulative impacts. In contrast, Dyekjaer et al. (1995) found that in Denmark, although local effects of short duration might occur, annual release of suspended particles by mobile fishing gear is relatively unimportant compared with that resulting from wind and land runoff. Chronic suspension of sediments and resulting turbidity can also affect aquatic organisms through behavioral, sublethal and lethal effects, depending on exposure. Species reaction to turbidity depends on life history characteristics of the species. Mobile organisms can move out of the affected area and quickly return once the disturbance dissipates (Simenstad 1990, Coen 1995). Even if species experience high mortality within the affected area, species with short life history stages and high levels of recruitment or high mobility can repopulate the affected area quickly. However, if effects are protracted and occur over a large area relative to undisturbed area, recovery through recruitment or immigration will be hampered. Furthermore, chronic resuspension of sediments may lead to shifts in species composition by favoring those species that are better suited to recover or those that can take advantage of the pulsed nutrient supply as nutrients are released from the seafloor to the euphotic zone (Churchill 1989).

C. Changes in Chemistry

Fishing gear can result in changes to the chemical makeup of both the sediments and overlying water mass through mixing of subsurface sediments and porewater. In shallow water this mixing might be insignificant in relation to that from tidal and storm surge and wave action, but in deeper, more stable waters, this mixing can have significant effects (Rumohr 1998). In a shallow, eutrophic sound in the North Sea, fishing caused an increase in average ammonia content (although horizontal variations prevented interpretations of these increases) and a decrease in oxygen due to the mixing of reduced particles from within the sediments (Reimann and Hoffman 1991). Also in the North Sea, fishing enhances phosphate released from sediment by 70-380 tonnes per year for otter trawls and by10,000-70,000 tonnes per year for beam trawlers (ICES 1992). These pulses were compensated by lower fluxes after the trawl passes. It is important to remember that these releases are recycling existing nutrients, rather than adding new nutrients, such as inputs from rivers and land runoff (ICES 1992). It is unclear how changes in chemistry might affect fish populations. During seasons when nutrients are low, the effective mixing of the sediments could cause increased phytoplankton primary production and/or eutrophication. ICES (1992) concluded, however, that these pulses are compensated by lower fluxes after the trawl has passed, and that the releases from fishing gear that recycle existing nutrients are probably less influential than new inputs from rivers and land runoff (ICES 1992).

D. Changes to Benthic Community

Benthic communities are affected by fishing gear through damage to the benthos in the path of the gear and disturbance of the seafloor to a depth of up to 30 cm. Many kinds of epibenthic animals are crushed or buried, while infauna is excavated and exposed on the seabed. This is in addition to smothering addressed above. Specific impacts from fishing depend on the life history, ecology and physical characteristics of the biota present (Bergman and Van Santbrink 2000). Mobile species that exhibit high fecundities and rapid generation times will recover more quickly than non-mobile, slow-growing organisms. In Mission Bay, California, polychaetes with reduced larval phases and postlarval movements had small-scale dispersal abilities that permitted rapid recolonization of disturbed patches and resulted in maintenance of high infaunal densities (Levin 1984). Those with longlived larvae were only available for successful recolonization if the timing of disturbance coincided with periods of peak larval abundance, however, these species were able to colonize over much larger distances. Rijnsdorp and Van Leeuwen (1996) found increased growth (based on back calculated growth from otolith growth zones) in the smallest size classes of plaice in the North Sea correlated to eutrophication and seabed disturbance from beam trawls. The authors hypothesized that trawling caused a shift in the benthic community from low-productive, longlived species to high-productive, short- lived species that benefitted from increased nutrient availability due to anthropogenic activities. This potentially could have lead to increased prey availability, and thus, higher growth rates for the juvenile plaice. The physical structure of biota also affects their ability to sustain and recover from physical impacts with fishing gear. Thin shelled bivalves and starfish show higher damage than solid shelled bivalves in fished areas (Rumohr and Krost 1991). Animals that are able to retract below the surface of the seafloor or live below the penetration depth of the fishing gear will sustain much less damage than epibenthic organisms. Animals that are more elastic and can bend upon contact with fishing gear will suffer much less damage than those that are hard and inflexible (Eno et al. 2001). Kaiser et al. (2000a) found that chronic fishing around the Isle of Mann, UK had removed large-bodied fauna such that benthic communities are now dominated by smallerbodied organisms that are less susceptible to physical disturbance. Off the northwest shelf of Australia, a switch of dominant species from lethrinids and lutjanids (which are almost exclusively associated with habitats supporting large epibenthos) to saurids and nemipterids (which were found on open sand) occurred after removal of epibenthic fauna by trawling (Sainsbury et al. 1993, 1994).

Increased fishing pressure can also lead to changes in distribution of species, either through movement of animals away from or towards the fished area (Kaiser and Spencer 1993, 1996a, Ramsay et al. 1996, Kaiser and Ramsay 1997, Ramsay et al. 1998, Bradshaw et al. 2000, Demestre et al. 2000). Frid and Hall (1999) found higher prevalence of fish remains and scavengers and a lower abundance of sedentary polychaetes in stomach contents of dabs in the North Sea in areas of higher fishing effort. Kaiser and Spencer (1994) document that gurnards and whiting aggregate over beam trawl tracks and have higher numbers of prey items in their stomachs shortly after trawling. Based on these studies, researchers have speculated that mobile fishing may lead to increased populations of species that exhibit opportunistic feeding behavior. Fonds and Groenewold (2000) modeled results for the southern North Sea indicating that the annual amount of food supplied by beam trawling is approximately 7% of the food demand of common benthic predators. This level could help maintain populations but is insufficient to support further population growth.

E. Changes to Ecosystem

As discussed above, the use of some types of fishing gear can affect benthic community composition. It is possible that these changes at the community level are in turn resulting in effects on harvested populations and ecosystems. Ecosystem changes are not specifically addressed in this report due to the lack of research concerning ecosystem effects due to fishing activities.

Jones 1992

Jones, J.B., 1992. Environmental impact of trawling on the seabed: A review. New Zealand Journal of Marine and Freshwater Research, 1992, Vol. 2. 6: 59-67.

ABSTRACT

Fishers have been complaining about the effects of bottom trawl gear on the marine environment since at least the 14th century. Trawl gear affects the environment in both direct and indirect ways. Direct effects include maping and ploughing of the substrate, sediment resuspension, destruction of benthos, and dumping of processing waste. Indirect effects include post-fishing mortality and long-term trawl-induced changes to the benthos. There are few conclusive studies linking trawling to observed environmental changes since it is difficult to isolate the cause. However, permanent faunal changes brought about by trawling have been recorded. Research has established that the degree of environmental perturbation from bottom trawling activities is related to the weight of the gear on the seabed, the towing speed, the nature of the bottom sediments, and the strength of the tides and currents. The greater the frequency of gear impact on an area, the greater the likelihood of permanent change. In deeper water where the fauna is less adapted to changes in sediment regimes and disturbance from storm events, the effects of gear take longer to disappear. Studies indicate that in deep water (>I000 m), the recovery time is probably measured in decades.

Kaiser et al. 1996

Kaiser M. J., D. B. Edwards, B. E. Spencer, 1996. Infaunal community changes as a result of commercial clam cultivation and harvesting. Living Aquatic Resources 9:57-63.

ABSTRACT

Manila clams, *Tapes philippinarum* (Adams and Reeve) are cultivated beneath plastic netting, to protect them from excessive predation, and harvested after approximately two years. Both the on-growing and harvesting process have the potential to alter benthic communities. In order to study these effects, we surveyed a clam lay and uncultivated areas at a site of commercial clam cultivation in south-east England. Surveys were undertaken at the end of the growing stage, immediately after harvesting by suction dredge and seven months later. Infaunal abundance was greatest within a net covered clam lay than in proximate and distant control areas, but the total number of species encountered was similar in al1 areas (20-22). These differences were not attributable to variation in sediment structure or environmental variables between the areas sampled. Tube-building polychaetes, such as *Lunice conchilega* and *Euclymene lumhricoides*, were particularly abundant within the

cultivated area as was the errant polychaete, *Syllis gracilis*. Harvesting by suction dredge altered sediment composition by removing the larger sand fractions down to the underlying clay substratum, consequently there was a large reduction in the density of al1 individuals and the total number of species. Seven months later, no significant difference was found between the infaunal community in the harvested clam lay or either of the control areas and sedimentation had nearly restored the sediment structure. These observations indicate that the practice of clam cultivation does not have long-term effects on the environment or benthic community at this site.

LIS 2004

LIS 2004. *Long Island Sound symposium: A study of benthic habitats*. A report by the Connecticut Academy of Science and Engineering for the Connecticut Energy Advisory Board. November, 2004. Available online at: www.ctcase.org/reports/LIS.pdf

EXECUTIVE SUMMARY *Excerpt:*

Impact Analyses

EMF
No electric field is produced outside the shielded conductors of submerged cable installations. Additionally, the magnetic field produced in the operation of a cable is weak and at a level similar to that produced by the earth's magnetic field. Therefore, it is not expected that EMF generated by the operation of a submerged cable will have any impact on flora and fauna communities. If desired, existing measurement methods can be used to detect EMF from existing cables to confirm the values predicted in project planning.

Temperature
The low rate of steady-state energy dissipation from installed electric cables cannot have a significant impact on LIS given its large mass of water and rapid circulation. Therefore, the concern regarding temperature is more with the location of this energy transfer into the sediment layer and bottom boundary. In general, cables are designed so that during their operation, sediments located near a cable do not dry out. Under these conditions, little temperature rise is expected at the sediment-water interface. The thermal conductivity of the sediment layer, coupled with the known energy losses from the electric cables, will allow for accurate predictions of temperatures throughout the sediment layer — predictions that can be confirmed by careful measurements. Biologists will be able to evaluate these temperatures and predict if there will be any negative impacts on flora or fauna from these temperature changes. It is expected that, although there will be some change in temperature in the sediment immediately surrounding a cable, the depth of the cable's burial and insulating factors of the cable will minimize the impacts, if any, on the benthic habitats located in its immediate vicinity. Since pipelines operate at near-ambient temperatures, it is not expected that their operation will cause any negative impacts due to temperature.

Safety Issues and Impacts

An anchor striking a submerged object was the main safety issue addressed during the symposium. Some of the older electric cables are fluid-filled, contributing to the potential environmental impacts of a broken cable. However, more recent cables don't have a fluid component, which eliminates one of the potential environmental consequences of a severed cable. Safety systems installed on existing electric cables in LIS are equipped with high speed circuit breakers that very quickly de-energize a cable in case of an anchor strike of other equipment snag. These systems eliminate any hazard to the public from the release of energy caused by a break in a cable.

Several panelists were involved in projects that used engineered materials to provide protection for cables and pipelines. Most recently, this method was used to protect a section of the Hubline, a submerged natural gas pipeline located in Boston Harbor. These same materials can also be applied to submerged electric or telecommunication cables. The effects on benthic habitat of materials used to armor cables and pipelines need to be better understood. It is suggested that the planning phase of a project should include a risk assessment to determine the degree to which areas along a project's proposed route are susceptible to anchors strikes and thus worthy of protection. Additionally, it is suggested that a risk assessment for a pipeline project include an analysis of any impacts or hazards caused by a sudden release of compressed natural gas between the pipeline's isolation valves.

Installation and Maintenance Impacts

Initial installation and subsequent maintenance activities can be expected to produce repeated sea bottom disturbances from virtually any encroachment into LIS. Given that any infrastructure project will require occasional maintenance, and possibly removal at the end of its design life, it is suggested that cumulative impacts of infrastructure projects should be considered. It is generally understood that initial impacts can be expected to last for months, with long-term effects possibly lasting for years. For example, there may be a rapid return of biomass, though not necessarily recovery, to a disturbed area, but it may take longer for a more typical bottom benthic community to be rebuilt. However, the precise nature of the impacts, as well as the sedimentary conditions, both in shallow and deep water, that are needed to minimize impacts on the various benthic habitats, need to be better understood. Additionally, habitat restoration efforts, such as valuable shellfish beds, need to be completed in a manner so as to restore such areas to pre-construction productivity, or provide compensation for the loss of productivity of these impacted areas.

It appears that the industry is continuing to seek methods to minimize the impacts of the installation and maintenance of cables and pipelines. Certain methods, such as horizontal drilling, can currently transit areas up to 7,200 feet with little or no impact to the surface over which the cable or pipeline is installed. Also, the timing of construction activity should be planned to minimize its effects on the benthic community and life within the water column.

Aesthetics
The question of the aesthetics of LIS was not included in the scope of this project, but was added to this report in order to identify it as an issue that may need to be considered in the future. It is suggested that the value of LIS cannot be measured simply in the value of fish produced or other economic criteria. Consideration should be given to identifying a value that can be applied to the aesthetic enjoyment of the Sound's open surface and long vistas with regard to the evaluation of projects that may be considered for placement on the surface of or above LIS.

Ocean Surveys, 2005

Thirty Month Post-Installation Benthic Monitoring Survey for the Cross Sound Cable Project, prepared by Ocean Surveys, Inc., 91 Sheffield St., Old Saybrook, CT 06475, for Cross-Sound Cable Company, LLC, 110 Turnpike Road, Suite 300, Westborough, MA 0 158, May 27, 2005.

The Cross Sound HVDC Cable was placed beneath 27-miles of Long Island Sound in 2003.

EXECUTIVE SUMMARY
The Thirty Month Post-Installation Benthic Monitoring Survey is the fourth and final of the planned monitoring surveys designed to document benthic conditions following installation of the Cross Sound Cable. The surveys were conducted by Ocean Surveys, Inc between 14 February and 18 March 2005. The monitoring consisted of a series of remote sensing surveys to characterize the bottom conditions in five 1000 foot long areas (representative of various benthic characteristics) centered over the cable in New Haven Harbor and Long Island Sound.

This benthic monitoring is being performed to satisfy cable installation permit conditions established by the U.S. Army Corps of Engineers' (ACOE) and the State of Connecticut Department of Environmental Protection's (CTDEP). Procedures are consistent with the Pre- and Post-Installation Benthic Monitoring Plan approved by the Connecticut Siting Council; CTDEP, Office of Long Island Sound Programs; CTDEP Division of Marine Fisheries; the Connecticut Department of Agriculture, Bureau of Aquaculture; the U.S. Army Corps of Engineers; and the National Marine Fisheries Service.

Since the 18 month post-installation survey, events have occurred that are relevant to the results obtained from the latest 30 month monitoring phase. From October 2003 to January 2004, the U.S. Corps of Engineers conducted maintenance dredging in the federal navigation channel in New Haven Harbor. Also, Cross-Sound Cable Company, LLC conducted cable reburial operations in New Haven Harbor from October 2004 to January 2005. Aside from outages required by transmission system constraints, the cable system was energized and operational during the 30 month post-installation survey.

Results from the 30 month multibeam and side scan sonar data indicate sediment has accumulated over the past year and a half within the linear depression marking the path of cable installation (termed 'cableway') in Areas 1 and 5. This accumulation is suggestive of a small amount of deposition from outside sources, the reworking of existing sediments around the feature, or a combination of both processes. The thickness of this surficial layer is typically less than 0.5 feet. Little or no sediment accumulation was detected in Area 3. No evidence of cable installation was detected in Area 4 (6 month, 18 month, or 30 month surveys) due to the dynamic nature of conditions at this site. The six benthic habitat types identified from the preinstallation survey still exist within the five study areas. These habitats range from the coarsest material (Habitat #l; coarse sand-gravel-cobbles-boulders) to the finest material (Habitat #6; clay). The only visible and measurable changes in substrate characteristics from the sediment profile imagery (SPI) are in Areas 1 where a variable, surficial layer comprised of fine sediment (silt-clay) is evident at most stations. Potential sources for this sediment layer include the recent Corps of Engineers channel dredging project, shellfish harvesting, and deep draft commercial vessels whose propellers occasionally stir up the bottom. The thin layer observed in Area 5 during the 18 month survey is no longer evident.

The detailed analysis of the sediment profile images reveals no significant difference between benthic habitats located within and outside the cable embedment area. Benthic assemblages and communities observed on the seabed remained consistent with previous monitoring phases. Physical or combined biological/physical processes dominated the sediment surface at all five areas during the 30 month post-installation survey. This dominance was most apparent in the distribution of sediment grain size and bedforms. Pure sandy sediments, indicative of high kinetic energy bottoms, were seen at all stations in Area 4 and most in Areas 1 and 5. Bedforms were present at all sandy stations in Areas 4 and 5, with the most pronounced features evident in Area 4 where thick, well-sorted medium to coarse sands exist. Sediments at all stations in Area 3 were silty-clay.

Sediment compaction, a SPI parameter measured by the extent of camera prism penetration, is generally related to sediment grain size, whereby coarser materials (sand, gravel, cobbles) usually allow less penetration than finer grained sediments (silt, clay). Prism penetration results in all areas show no significant difference between stations located within the cableway and stations outside the cableway in undisturbed bottom areas.

The importance of biological processes in structuring surface sediments increased with the seasonal recruitment benthic fauna that occurred between the May 2002 pre-installation and October 2002 6-month post installation surveys. By the December 2003 18-month postinstallations the importance of biological processes declined. Biological processes following the winter of 2004/2005 were more prominent during the March 2005 30-month postinstallation survey. This was an expected response to the seasonal progression from spring to summer to fall to winter conditions. Each of the areas sampled appeared to represent part of the mosaic of different benthic habitat types known to exist in Long Island Sound (Zajac et al. 2000, Zajac 2001).

Area 3 near the center of the Sound had the highest benthic habitat quality for all of the surveys (Table 5). Habitat quality in Areas 1, 2, 4, and 5 was more variable. In general, Area 4 near the southern shoreline of the sound had the most physically dynamic habitats with wave dominated clean-sand bottoms with little to no evidence of biogenic structures. This led to Area 4 being ranked as a lower quality habitat area, however the paradigms used in assessing habitat quality were not developed for such physically dynamic bottoms. Areas 1, 2, and 5 were primarily physically dominated habitats but there was evidence of biogenic activity, which would tend to rank them higher in habitat quality than Area 4.

Results from the 30 month monitoring suggest that the benthos within the cableway is continuing to return pre-installation conditions. The presence of amphipod and worm tube mats at a number of stations within the cableway are indicators that suggest the construction activities associated with cable installation did not have a long term negative effect on the potential for benthic recruitment to surface sediments. Assumptions made about the RPD layer and successional stage in this report led to conservative estimates of the OSI and thus benthic habitat quality. The actual OSI, and hence habitat condition, is believed to be higher than estimated in the five study areas.

The measured magnetic compass declination or variation has remained the same since the preinstallation survey. A comparison of the measured declination and expected declination (calculated using an official geomagnetic equation) at each area indicates there is no measurable change to the magnetic declination in the five study areas. Also, the measured variation in each of the five study areas located over the Cross Sound cables remained consistent with the variation recorded in the Reference Area where there is no submarine power cable present. No anomalous (unusually high or low) magnetic field readings were detected in any of the study areas. There is no evidence to suggest that the presence of the power cables will affect vessel navigation on the water surface.

HDR 2008

Shellfish Monitoring Program, Draft Report, July 2008**,** HDR, Inc., 1 Blue Hill Plaza, Pearl River, NY 10965

Neptune RTS is a 65-mile, 660 megawatt HVDC transmission line buried in Raritan Bay and the Atlantic Ocean off of Long Island in 2007 and 2008. Following is a summary of effects observed among surf clams populations along the route.

Shellfish: For surf clams, the size structure at sample stations either increased from the pre-installation to the 3-month and 15-month post-installation surveys or stayed consistent between the surveys. Surf clams collected during the 15-month post-installation survey were either larger or within range of prior studies, indicating that the cable installation process has not affected growth.

The CPUE estimates for the pre-installation, 3-month post-installation and 15-month postinstallation surveys were lower than mean CPUEs calculated for similar locations by the NYSDEC during their 2002 Atlantic Ocean surf clam population assessment (NYSDEC 2002).

Only the CPUE estimate for SC-3 during the pre-installation survey was higher than the NYSDEC values. However, at all stations (the Neptune RTS pre-installation, 3-month postinstallation and 15-month post-installation survey) CPUE estimates were within the range of CPUEs calculated during the NYSDEC survey.

The histological results indicated no sign of infection or parasites among surf clams collected during the pre-installation survey. Although the frequency of Chlamydial inclusions increased from zero to six of the eight stations in the 3-month post-installation survey and seven of eight stations in the 15-month post-installation survey, however this microbe is commonly found and not considered pathogenic to shellfish.

There appeared to be no significant impacts to the shellfish beds as of 15 months after the cable installation. There were no inflammatory responses in the gills, pericardium, or mantle, no lesions, and, in hard clams, no substantial increases in QPX over baseline levels. Clams at all stations appeared in good condition during each survey.

The results of the Neptune RTS shellfish monitoring program and available literature suggest shellfish beds surrounding the cable route were not impacted by sediment resuspension associated with the project.

HDR/LMS 2007

Pre- & Post-Installation Fisheries Survey Report For the Neptune Regional Transmission System, LLC Submarine Cable Route, August 2007, prepared by HDR/LMS One Blue Hill Plaza
Pearl River, NY 10965

Similar species richness was observed during the fisheries surveys, with 18 species collected during the pre-installation survey and 15 collected during the post- installation survey.

The survey results provide a temporal and spatial snapshot of a dynamic fisheries population interacting with multiple biological and physical factors that influence fish migrations and habitat use. Comparison of CPUE between the pre- and post-installation surveys indicates that the in water construction activities associated with cable installation did not result in any project related direct or indirect impacts on the fisheries populations in the project area.

Ohman et al. 2007

Ohman, M.C., P. Sigray, and H. Westerberg. 2007 Offshore Windmills and the Effects of Electromagnetic Fields on Fish, Ambio Vol. 36, No. 8, December 2007.

ABSTRACT

With the large scale developments of offshore windpower the number of underwater electric cables is increasing with various technologies applied. A wind farm is associated with different types of cables used for intraturbine, array-to-transformer, and transformer-to-shore transmissions. As the electric currents in submarine cables induce electromagnetic fields there is a concern of how they may influence fishes. Studies have shown that there are fish species that are magneto-sensitive using geomagnetic field information for the purpose of orientation. This implies that if the geomagnetic field is locally altered it could influence spatial patterns in fish. There are also physiological aspects to consider, especially for species that are less inclined to move as the exposure could be persistent in a particular area. Even though studies have shown that magnetic fields could affect fish, there is at present limited evidence that fish are influenced by the electromagnetic fields that underwater cables from windmills generate. Studies on European eel in the Baltic Sea have indicated some minor effects. In this article we give an overview on the type of submarine cables that are used for electric transmissions in the sea. We also describe the character of the magnetic fields they induce. The effects of magnetic fields on fish are reviewed and how this may relate to the cables used for offshore wind power is discussed.

Gill et al. 2009

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. 2009. COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the off shore renewable energy industry. Collaborative Off shore Windfarm Research, London, U.K. 128 pp., www.offshorewindfarms.co.uk/Assets/COWRIE_2_EMF_FINAL_REPORT_Combined_09.pdf

Project Conclusions

Overall, the COWRIE 2.0 EMF mesocosm study and wind farm surveys have provided evidence that the benthic, elasmobranch species studied can respond to the presence of EMF that is of the type and intensity associated with sub-sea cables. The response is not predictable and appears to be species specific and perhaps individual specific, meaning that some species and their individuals are more likely to respond by focussing movement within the zone of EMF. We found that when there was EMF emitted some Thornback Rays were more likely to move around within the EMF zone associated with the cable and a number of Catsharks were found nearer to the cable and they restricted their movement within the EMF area, which is consistent with species specific behavioural activity that is associated with feeding in these elasmobranchs.

Furthermore, the field measuring of EMF at offshore wind farms sites showed that there are both magnetic and electric field emissions associated with the main feeder cables to shore and these EMFs are comparable, and in some cases, greater than the EMF produced in the experimental mesocosm study. The zone of EMF that is potentially within the range of detection of the elasmobranch spans several hundred metres.

The project has met its objective by demonstrating that some electrosensitive elasmobranchs will respond to the EMF emitted in terms of both the overall spatial distribution of one of the species tested and at the finer scale level of individual fish of different species. Considering the novelty, the enormity of the logistics and the uniqueness of the project we are very satisfied that the experimental phase of the project has been completed successfully and addressed the main objective set out in the COWRIE 2.0 EMF project specification.