Tidal Energy – Environmental Impacts

"The Skerries Tidal Stream Array Environmental Impact Assessment Scoping Report" Marine Current Turbines Limited July 2006
Discussion of environmental impacts from proposed 7 unit tidal energy array in UK.

"South Stack Tidal Stream Array Environmental Impact Assessment Scoping Report" Marine Current Turbines Limited July 2006
Discussion of environmental impacts from proposed 7 unit tidal energy array in Wales, UK.

A.S. Bahaj and L.E. Myers "Fundamentals applicable to the utilization of marine current turbines for energy production" Elsevier April 2003
Paper addresses the issues, such as the harsh marine environment, phenomenon of cavitation (formation and collapse of bubbles under changing pressure), and other stresses encountered by tidal energy structures.

Bryden, Ian and Scott Couch, "ME1 – marine energy extraction: tidal resource analysis" Elsevier Renewable Energy 31 (2006): 133-139.
Paper examines issues to consider when analyzing the extraction of tidal resources, including impacts of energy extraction on the underlying resources.

Fraenkel, Peter "Tidal Current Energy Technologies" Ibis 148 (2006): 145-151.
Paper examines needs for tidal energy generation, and environmental impacts.

Johnstone, C., K. Nielsen, T. Lewis, A. Sarmento, G. Lemonis "EC FPVI co-ordinated action on ocean energy: A European platform for sharing technical information and research outcomes in wave and tidal energy systems" Elsevier Renewable Energy 31 (2005): 191-196.
Paper addresses the coordinated action in the title, to promote the development of commercially viable wave and tidal energy installations.

Myers, L. and A.S. Bahaj. "Simulated electrical power potential harnessed by marine current turbine arrays in the Alderney Race" Elsevier 30 (2005): 1713-1731.
Paper examines design details of a tidal current turbine.

MS Word document summarizing various studies of tidal power. Includes the abstracts and reference details.

New Zealand Aotearoa Wave and Tidal Energy Association "Environmental Impacts of Marine Energy Converters" November 2008

Wave Energy – Environmental Impacts

"Wave Energy Utilization in Europe: Current Status and Perspectives" Centre for Renewable Energy Sources, Greece 2002
A report on wave energy aspects.

Johnstone, C., K. Nielsen, T. Lewis, A. Sarmento, G. Lemonis "EC FPVI co-ordinated action on ocean energy: A European platform for sharing technical information and research outcomes in wave and tidal energy systems" Elsevier Renewable Energy 31 (2005): 191-196.
Paper addresses the coordinated action in the title, to promote the development of commercially viable wave and tidal energy installations.

Kofoed, J., P. Frigaard, E. Friis-Madsen, H. Sorensen "Prototype testing of the wave energy converter wave dragon" Elsevier Renewable Energy 31 (2006): 181-189.
Discusses this over-topping wave energy technology.

Thorpe, T. "An Overview of Wave Energy Technologies: Status, Performance and Costs" 1999.
Paper compares various wave energy technologies.

Thorpe, T "Economic Analysis of Wave Power Devices" 1999.
Assessment of various wave energy technologies.

New Zealand Aotearoa Wave and Tidal Energy Association "Environmental Impacts of Marine Energy Converters" November 2008

Birds, Bats and Wind Turbines

Barrios, L. and A. Rodriguez "Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines" Journal of Applied Ecology 41 (2004): 72-81.
Paper examines bird mortality from wind turbines (land-based), and concludes that new wind installations must be preceded by detailed observation of soaring birds and mapping of migration routes.

L. Bejder, A. Samuels, H. Whitehead, H. Finn, and S. Allen "Impact assessment research: use and misuse of habituation, sensitization and tolerance in describing wildlife responses to anthropogenic stimuli" Inter-Research 2009
Paper examines misuse of wildlife behavioral terminology in research that result in management conclusions that may be harmful to wildlife.

Blew, Jen, Malte Hoffman, Georg Nehls, Veit Hennig "Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Part I: Birds" BioConsult SH 2008
Study involved use of radar and observation over several days (100+) at existing wind farms. Some results are inconclusive with regard to impacts on birds, but lessons learned include migrants avoid the windfarms (with subsequent loss of habitat), and residents may become habituated, though with continued risk for collision. Nighttime and harsh weather data are needed, but may be difficult to attain.

Birds, Bats and Wind Turbines, continued

Blew, Jan, Malte Hoffmann, Georg Nehls "Collision risks at sea: Species composition and altitude distributions of birds in Danish offshore wind farms" BioConsult SH 2007
Study investigates collision risks of birds in operating wind farms.

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
A comprehensive plan examining developing renewable technologies and possible impacts these may have on the marine environment, Wales. *

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
Figures1: maps of possible renewable energy locations, Wales

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
Figures2: maps of possible renewable energy locations, Wales

Desholm, Mark and Johnny Kahlert "Avian collision risk at an offshore wind farm" The Royal Society Biology Letters 1 (2005): 296-298.
Paper on radar observations of geese and duck behavior migrating through windfarms, finding daytime avoidance by flight above turbines, and nighttime avoidance by flight between turbines.

Diederichs, Ansgar, Veit Hennig, Georg Nehls "Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Part II: Harbour Porpoises" BioConsult SH 2008
Paper finding no effects of wind farms on harbor porpoises.

Drewitt, Allan and Rowena Langston "Assessing the impacts of wind farms on birds" Ibis 148 (2006): 29-42.
Paper addresses effects on birds from land-based wind farms, noting there is a pressing need for more information on the range of potential impacts.

Erickson, W., G. Johnson, M. Strickland, D. Young, K. Sernka, R. Good "Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States" National Wind Coordinating Committee Resource Document 2001
Paper is a literature review of various threats to birds from human-made sources.

Gill, Andrew "Offshore renewable energy – ecological implications of generating electricity in the coastal zone" Journal of Applied Ecology 42 (2005): 605-615.

Birds, Bats and Wind Turbines, continued

Paper demonstrates that offshore renewable energy installations will have direct and possibly indirect consequences for coastal ecology with effects occurring at different scales. Recommends ecological evaluation of individual projects.

Inger, Richard et al "Marine renewable energy: potential benefits to biodiversity? An urgent call for research" Journal of Applied Ecology 46 (2009): 1145-1153.
Paper finds that there is potential for both benefits and detriments to the environment from marine renewables, but more research is needed. Key consideration is whether renewable energy installations should be designed to minimize environmental impacts, or as facilitators of ecosystem restoration.

Maclean, I., L. Wright, D. Showler, M. Rehfisch, "A Review of Assessment Methodologies for Offshore Windfarms" Cowrie May 2009
A review of survey methods (aerial and boat) for surveying birds in off-shore wind farms.

Thaxter, Chris and Niall Burton "High Definition Imagery for Surveying Seabirds and Marine Mammals: A Review of Recent Trials and Development of Protocols" Cowrie November 2009.
Goal of report is to review trials of this avian and marine mammal survey technology, and to make recommendations on protocols for its use.

Tall Structures and Birds/Bats Information Group Newsletter, Volume 4 (2007)
Article on a study of bird collision risk at offshore wind plants, and others.

Wilson, B. et al "Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive" Scottish Association for Marine Science March 2007.
Paper summarizes collision risks for mammals, fish and diving birds.

Drewitt, Allan and Rowena Langston "Assessing the impacts of wind farms on birds" Ibis 148 (2006): 29-42.
Paper examines four main effects of wind farms on birds: collision, displacement due to disturbance, barrier effects and habitat loss.

Ahlen, Ingemar et al "Bats and offshore wind turbines studied in southern Scandinavia" Swedish Environmental Protection Agency 2007.
Paper examines where bats are found around offshore turbines, and their interactions with turbines.

Barrios, L. and A. Rodriguez "Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines" Journal of Applied Ecology 41 (2004): 72-81.
Paper examines bird mortality from wind turbines (land-based), and concludes that new wind installations must be preceded by detailed observation of soaring birds and mapping of migration routes.

Birds, Bats and Wind Turbines, continued

Gill, Andrew "Offshore renewable energy – ecological implications of generating electricity in the coastal zone" Journal of Applied Ecology 42 (2005): 605-615.
Paper demonstrates that offshore renewable energy installations will have direct and indirect consequences for coastal ecology with effects occurring at different scales. Recommends ecological evaluation of individual projects.

Arnett, Edward et al "Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia" Final Report for the Bats and Wind Energy Cooperative June 2005.
Research finds that forested ridges are locations of especially high risk for bat fatalities from wind facilities.

Desholm, M et al "Remote techniques for counting and estimating the number of bird-wind turbine collisions at sea: a review" Ibis 148 (2006): 76-89.

Nicholls, Barry and Paul Racey "The Aversive Effect of Electromagnetic Radiation on Foraging Bats – A possible Means of Discouraging Bats from Approaching Wind Turbines" PLos One 4 (2009).

Chamberlain, Dan et al "The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models" Ibis 148 (2006): 198-202.
Paper evaluates the accuracy of collision risk models in predicting bird collisions with wind turbines.

Marine Mammals and Wind Turbines
Brandt, Miriam et al "The use of seal scarers during offshore pile driving – an effective mitigation measure for harbour porpoises?" (Poster) BioConsult SH 2010
Poster examines the impacts of seal scarers on acoustic activity of harbor porpoises, finding acoustic activity lower during seal scarer operation than before or after.

Carstensen, J., O. Henriksen, J. Teilmann "Impacts of offshore wind farm construction on harbor porpoises: acoustic monitoring of echo-location activity using porpoise detectors (T-PODs)" Inter-Research 321 (2006): 295-308.
Paper examines effect of construction on porpoise echolocation activity, finding that porpoises left the construction area of the windfarms examined.

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
A comprehensive plan examining developing renewable technologies and possible impacts these may have on the marine environment, Wales.

Marine Mammals, continued

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
Figures1: maps of possible renewable energy locations, Wales

"Potential Nature Conservation and Landscape Impacts of Marine Renewable Energy Developments in Welsh Territorial Waters" ABP Marine Environmental Research, Ltd. 2006
Figures2: maps of possible renewable energy locations, Wales

Diederichs, Ansgar, Veit Hennig, Georg Nehls "Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark, Part II: Harbour Porpoises" BioConsult SH 2008
Paper finding no effects of wind farms on harbor porpoises.

Gill, Andrew "Offshore renewable energy – ecological implications of generating electricity in the coastal zone" Journal of Applied Ecology 42 (2005): 605-615.
Paper demonstrates that offshore renewable energy installations will have direct and possibly indirect consequences for coastal ecology with effects occurring at different scales. Recommends ecological evaluation of individual projects.

Inger, Richard et al "Marine renewable energy: potential benefits to biodiversity? An urgent call for research" Journal of Applied Ecology 46 (2009): 1145-1153.
Paper finds that there is potential for both benefits and detriments to the environment from marine renewables, but more research is needed. Key consideration is whether renewable energy installations should be designed to minimize environmental impacts, or as facilitators of ecosystem restoration.

IFAW publication: "Ocean Noise: Turn it down, A report on ocean noise pollution"
Report discusses effects of man-made marine noise on marine animals.

Nedwell, J., J. Langworthy and D. Howell. "Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms, and comparison with background noise" Cowrie May 2003.

Parsons, E.C.M. et al. "A critique of the UK's JNCC seismic survey guidelines for minimizing acoustic disturbance to marine mammals: Best practise?" Elsevier Marine Pollution Bulletin 58 (2009): 643-651.
Paper discusses existing guidelines for minimizing disturbance to marine mammals during seismic surveys and questions their basis in fact, and efficacy.

Petersen, Jens and Torleif Malm "Offshore Windmill Farms: Threats to or Possibilities for the Marine Environment" Ambio 35 (2006)

Marine Mammals, continued

Paper examines impacts from large offshore windfarm, including noise, vibrations, electromagnetic fields, foundations and reef effect, scour, etc.

Brandt, Miriam et al. "Effects of pile driving on the distribution patterns of harbour porpoises in the North Sea (poster)" BioConsult SH 2009.

Stone, C.J. "The effects of seismic activity on marine mammals in UK waters 1998-2000" JNCC Report No. 323 (2003).
Marine mammals experience seismic survey disturbances differently; evidence that noise/vibrations from seismic surveys will result in avoidance behaviors among some marine mammals.

Thaxter, Chris and Niall Burton "High Definition Imagery for Surveying Seabirds and Marine Mammals: A Review of Recent Trials and Development of Protocols" Cowrie November 2009.
Goal of report is to review trials of this avian and marine mammal survey technology, and to make recommendations on protocols for its use.
Tougaard, J., et al "Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (Phocoena phocoena (L.))" Acoustical Society of America 126 (2009).
Paper finds that pile driving for steel monopile foundations for offshore wind turbines affected echolocation events for harbor porpoises.

Tougaard, J., et al "Underwater noise from three types of offshore wind turbines: Estimation of impact zones for harbor porpoises and harbor seals" Acoustical Society of America 125 (2009).
Paper finds that porpoises will likely not have behavioral reactions unless they are very close to the foundation; seals may have behavioral reactions for a few hundred meters from turbine foundations.

Tougaard, J et al "Effects of the Horns Reef Wind Farm on harbor porpoises: Interim report to Elsam Engineering A/S for the harbor porpoise monitoring program" National Environmental Research Institute (Denmark) September 2004.

Koschinski, Sven et al "Behavioural reactions of free-ranging porpoises and seals to the noise of a simulated 2 MW windpower generator" Marine Ecology Progress Series, Inter-Research 265 (2003): 263-273.
Paper finds that harbor porpoises and harbor seals are able to detect low-frequency sound generated by offshore wind-turbines. Simulated sound in Vancouver, Canada.

Boehlert, George et al "Ecological Effects of Wave Energy Development in the Pacific Northwest – A Scientific Workshop" NOAA NMFS October 2007.

Tougaard, Jakob et al "Final report on the effect of Nysted Offshore Wind Farm on harbour porpoises" Ministry of the Environment, Denmark July 2006

Marine Mammals, continued

Paper finds that 2 years after installation and operation of the Nysted Wind Farm, there are effects on harbor porpoise presence and echolocation activity, both in the farm area and in the greater Rodsand area.

Tougaard, Jakob et al "Harbour seals at Horns Reef before, during and after construction of Horns Rev Offshore Wind Farm" Final Report to Vattenfall A/S October 2006
Report finds that underwater noise from turbines appears to have a marginal impact on harbor seals in this area. Scour protection may create increased food supply.

Diederichs, Ansgar, Veit Hennig, and Georg Nehls "Investigations of the bird collision risk and the responses of harbour porpoises in the offshore wind farms Horns Rev, North Sea, and Nysted, Baltic Sea, in Denmark: Part II: Harbour Porpoises" Final Report BioConsult SH 2008.
Study concludes that operating offshore wind farms do not significantly induce aversive responses from harbor porpoises. Not sure about the title, as the summary does not address birds?

Gill, Andrew "Offshore renewable energy – ecological implications of generating electricity in the coastal zone" Journal of Applied Ecology 42 (2005): 605-615.
Paper demonstrates that offshore renewable energy installations will have direct and indirect consequences for coastal ecology with effects occurring at different scales. Recommends ecological evaluation of individual projects.

Tougaard, Jakob and Jona Teilmann "Rodsand 2 Offshore Wind Farm – Environmental Impact Assessment, Marine mammals" National Environmental Research Institute, Denmark January 2007.
Study looks at impacts to harbor porpoises, harbor seals, and grey seals.

Tougaard, Jakob et al "Satellite tracking of Harbour Seals on Horns Reef – Use of the Horns Reef wind farm areas and the North Sea" Report to Techwise A/S March 2003.
Study found that there was considerable variability in how the seals used the Horns Reef area.

Tougaard, Jakob et al "Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef" Technical Report to Techwise A/S April 2003
Study found that during construction period fewer porpoises appeared to be foraging in the construction zone.

Teilmann, Jonas, Jakob Tougaard and Jacob Carstensen "Summary on harbour porpoise monitoring 1999- 2006 around Nysted and Horns Rev Offshore Wind Farms" Report to Energi E2 A/S and Vattenfall A/S November 2006.
Report to the energy developers on impacts to porpoises: evidence of less echolocation activity at Nysted during construction and 2 years later. Speculation that stronger activity

Marine Mammals, continued

at Horns Rev may be due to higher motivation to find food, and/or generally noisier environment.

Teilmann, Jonas, Jakob Tougaard and Jacob Carstensen "Summary on seal monitoring 1999- 2005 around Nysted and Horns Rev Offshore Wind Farms" Report to Energi E2 A/S and Vattenfall A/S November 2006.
Study found no detectable difference in seal activity except during construction, reduction in seals resting on land.

Betke, Klaus Manfred Schultz-von Glahn, and Rainer Matuschek "Underwater noise emissions from offshore wind turbines" Presented at CFA/DAGA 2004.
Illustrates noise emitted from various turbines; does not comment on whether it will affect marine mammal behavior.

Tougaard, Jakob, Peter Madsen and Magnus Wahlberg "Underwater Noise from Construction and operation of offshore wind farms" Bioacoustics 17 (2008):143-146.
Paper observes that the effect of underwater noise on marine mammals will depend on many factors, including density of animals, importance of area to animals, sound transmission characteristics, and temporary displacement during construction.

Madsen, P, et al "Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs" Inter-Research 309 (2006): 279-295.
Paper examines implications of noise on marine mammals, concluding that noise impacts are greater during construction than operation.

Clark, C, et al "Acoustic masking in marine ecosystems: intuitions, analysis, and implication" Inter-Research 395 (2009): 201-222.
Paper presents an analytical paradigm to quantify changes in an animal's acoustic communication due to background noise.

Renewable Energy Impacts on Fish

Wilson, B. et al "Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive" Scottish Association for Marine Science March 2007.
Paper summarizes collision risks for mammals, fish and diving birds.

Muller, Christina "Behavioral reactions of cod (Gadus morhua) and plaice (Pleuronectes platessa) to sound resembling offshore wind turbine noise" Dissertation 2007
Thesis examines effect of pure tone sound on cod and plaice in experimental setting, finding that cod may be displaced for some period of time.

Boehlert, George et al "Ecological Effects of Wave Energy Development in the Pacific Northwest – A Scientific Workshop" NOAA NMFS October 2007.

Fish, continued

Hoffmann, Eric et al "Effects of marine windfarms on the distribution of fish, shellfish and marine mammals in the Horns Rev area" Report to Elsamprojeckt May 2000.
Report makes findings about expected reactions of harbor seals, porpoises, fish, etc. prior to installation of the Horns Rev Wind Farm.

Wahlberg, Magnus and Hakan Westerberg "Hearing in fish and their reactions to sounds from offshore wind farms" Marine Ecology Progress Series 288 (2005): 295-309.
Paper finds that noise from windmills may decrease hearing abilities of fish, but cautions that much more research is needed.

Gill, Andrew "Offshore renewable energy – ecological implications of generating electricity in the coastal zone" Journal of Applied Ecology 42 (2005): 605-615.
Paper demonstrates that offshore renewable energy installations will have direct and indirect consequences for coastal ecology with effects occurring at different scales. Recommends ecological evaluation of individual projects.

Renewable Energy Environmental Assessments

"Cape Wind Energy Project: Final Environmental Impact Statement" US Department of the Interior, Minerals Management Service January 2009
Environmental assessment for 130 proposed wind turbines in Nantucket Sound.

Davison, Alistair and Tom Mallows "Strangford Lough Marine Current Turbine Environmental Statement" Royal Haskoning, Ltd June 2005
Summary of impacts from installation of single tidal turbine in internationally significant resource waters in the UK.

Jones, Nia and Chris Wynne. "Scoping paper for Skerries tidal stream array project, Wales" September 2006.

Jones, Nia and Chris Wynne. "Scoping paper for South Stack tidal stream array project, Wales" September 2006.

South West of England Regional Development Agency "Wave Hub Environmental Statement" June 2006.
Environmental assessment of impacts of this electrical infrastructure on marine environment. The Wave Hub will facilitate wave energy converter development.

South West of England Regional Development Agency "Wave Hub Wave Monitoring Project, Interim Report Number 1" June 2009.
Report on data collection for the Wave Hub infrastructure project.

European Marine Energy Centre Environmental Impact Assessment Guidelines, 2008

Report discusses content for EIAs for energy projects in the EU.

Benthic and Pelagic Environment

Maar, Marie, Karsten Bolding, Jens Petersen, Jorgen Hansen, Karen Timmerman "Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark" Elsevier Journal of Sea Research 62 (2009): 159-174.
Paper finds that success of off-shore wind facilities scour protection as reef systems depends on relationship to benthic and pelagic environment.

Policy Tools

Sutherland, W. et al "Future novel threats and opportunities facing UK biodiversity identified by horizon scanning" Journal of Applied Ecology 45 (2008): 821-833.
Horizon scanning, as a policy tool, can be used by environmental policy makers and researchers to identify gaps in knowledge and policy.

Fischer, Carolyn and Richard Newell "Environmental and Technology Policies for Climate Change and Renewable Energy" Resources for the Future April 2004
Paper examines different policy options for reducing greenhouse gas emissions, including taxes or subsidies for various energy sources.

Inger, Richard et al "Marine renewable energy: potential benefits to biodiversity? An urgent call for research" Journal of Applied Ecology 46 (2009): 1145-1153.
Paper finds that there is potential for both benefits and detriments to the environment from marine renewables, but evidence is limited. Key consideration is whether renewable energy installations should be designed to minimize environmental impacts, or as facilitators of ecosystem restoration.