A further commentary on the unprecedented expansion of marine wind farms in the northern hemisphere.

Vicki C. James and Mark P. Simmonds[1]

Whale and Dolphin Conservation Society, Brookfield House, 38 St Paul Street, Chippenham, Wiltshire SN15 1LJ, UK.

Abstract

There is a rapid expansion of marine wind farms across the globe as governments strive to meet renewable energy commitments. Today in the northern hemisphere there are 484 such sites in various stages of development. The centre of the developments has been concentrated in European seas where there is the highest number of operational wind farms.

However, there are a larger number of sites in early planning and submission stages outside of Europe, in particular in China. This paper is an update to previous submissions to the IWC Scientific Committee concerning marine renewables and illustrates the scale and rapid expansion of wind farms in the northern hemisphere. We also consider what the role of the IWC Scientific Committee might be in helping to evaluate any impacts on cetacean populations and recommend that a workshop be held to help this.

Keywords: Marine renewable energy, cetaceans, noise, wind farms

Introduction

Significant gaps exist in our knowledge of the possible impacts on the environment resulting from the construction and operation of offshore wind farms (ICES, 2010). Nonetheless, concerns about their potential impacts, and those of other marine renewable developments, on cetaceans have recently been raised (for example, Simmonds and Brown, 2010 and previous submissions to the Scientific Committee on this issue). Both the IWC Scientific Committee and the International Council for the Exploration of the Seas have recently considered this matter (IWC, 2010 and ICES 2010). Last year the IWC's Standing Working Group on Environmental concerns (SWG) briefly considered some of the issues associated with the construction, operation, maintenance and decommissioning of wind, tidal and wave renewable energy technologies. Further to this, the IWC Scientific Committee '**strongly recommended'** that countries co-operate to limit impacts on marine wildlife from these sources'. The Committee also **endorsed** the relevant recommendations from the ICES Workshop (presented here for information as Annex 1).

[1] Corresponding author mark.simmonds@wdcs.org

It has been proposed that the marine renewable industry might negatively affect cetaceans in a variety of ways (Simmonds and Brown, 2010), including by increased noise levels; physical interactions, including collisions and entanglements; habitat changes; increased contamination; and effects on prey. Factors potentially moderating such impacts could include the nature of the foundations and the process used to establish them; the topography of the local seabed and the nature of the seabed substrate; and the scale of developments and the fact that developments may also be ongoing in neighbouring waters to produce synergistic impacts.

The number of marine wind farms being planned in the northern hemisphere continue to gather pace as governments strive to meet targets to reduce carbon emissions and, arguably, as a more publically-acceptable alternative to terrestrial wind farms. Provided here is an overview of the present state of wind farms in the northern hemisphere. The data gathered for each country are shown in table 1 below, and the locations of these wind farms are represented in figure 1. This is a rapidly changing picture, especially as plans for wind farms are continuously being submitted or granted, and we regard the information provided here as preliminary. We would be pleased to be provided with additions or corrections.

Methods

Information on the location and scale of wind farms was gathered through a survey of the web-based resources provided by various companies and governmental bodies, and a literature search. The locations of these wind farms were plotted on maps and are shown in figure 1. Table 1 shows the number of wind farms, area and total energy generation grouped by country.

Results

Several stages of development could be identified: Approved, Awarded, Concept/ Early Planning, Operational , Submitted, Under Construction, Withdrawn/ Rejected:

- 'Approved' sites are those for which the submitted plans have been consented to, but construction has not been started.
- 'Awarded' sites are those where developers have been granted exclusivity by the UK's Crown Estate to develop an offshore wind farm. At this stage only consent has been given to the developer and no plans have been drawn up or submitted. Once a site has been awarded, the developer makes a proposal to submit for the site.
- 'Concept/ Early Planning' sites are those where developers are drawing up plans for wind farms, and the details (size, no. of turbines etc.) are still being finalised.
- 'Operational' sites are those that have been completed and are providing electricity.
- 'Submitted' sites are those where plans have been completed and reports submitted for consideration. At this stage sites can either be approved or rejected.
- 'Under construction' sites are those that have been approved and construction is currently underway.
- 'Withdrawn/ Rejected' sites are those that submitted a plan, but it was either rejected based upon the submitted plans, or withdrawn by the developer.

When all the developments noted so far are considered together, their rapid expansion can clearly be seen. There are currently 39 sites operational in Europe of the 45 mapped so far, with concentrations around the UK coastline, in the North Sea, and along the Baltic Sea

coasts of Germany and Denmark. In Europe, Germany has the greatest number of wind farms with 117 in various stages of development, with 56 of these sites having been submitted and awaiting a decision.

Europe has been at the forefront of marine wind farm development, and using these same technologies, other countries now have wind farms in various stages of development. Outside of Europe, China has the largest number of wind farms with 84 in total, 61 of these are in the concept/early planning stage.

Wind farms range from demonstrator projects that are 1km^2 in size with 1 turbine, to a site of 543km^2 in Denmark, in the Kattegat, comprised of hundreds of turbines. The area covered by all wind farms combined is 9,081km^2 (these data are not available for all wind farms in all countries), with Germany having the largest known combined area of 5,122km^2 designated for their wind farms (taking into account all stages of development) and therefore also leading in total energy generation at 178,941MW capacity.

Conclusions

Given the rapid expansion of marine wind farms in the northern hemisphere, and their likely similar expansion in the southern hemisphere, it is important that the impacts of marine wind farms on the marine environment are fully understood. Brown and Simmonds (2010) previously noted that the impacts of wind farms on cetaceans are still relatively unknown and that "arguably the pile driving process during construction offers the greatest threat". Dolman *et al* (2007) highlighted the need to achieve robust baseline data before any development site is determined. This would help to facilitate the production of clear guidance for planners and developers for the protection of marine mammals. It would also help to inform any attempts at mitigation. Simmonds and Brown (2010) commented that not only is establishing baseline data essential but that "We would be in a much better position now to assess impacts if better baseline data has been available ahead of the wind farms now in operation". We also support the recommendation from Inger *et al*. (2009) and others to minimise potential conflicts by involving key stakeholders in the decision making process from concept, through stages of design, location, construction and operation.

It is inconceivable given the scale of marine renewable developments across the world that they will not impact on cetaceans, and they are not the only new factor in the seas that may cause problems for these animals. Marine renewable impacts will vary depending on the nature of local circumstances, the type of development in question and the associated activities, including but not limited to construction and increased vessel traffic. Marine renewables are also likely to impact different cetacean taxa in different ways but at the moment we have little other than well reasoned speculation to cite.

The IWC Scientific Committee is in an excellent position under its SWG to take forward work on this issue and there is a need for an independent, international review of the impacts of this rapidly expanding industry. So, further to the strong recommendation made last year by the Scientific Committee calling on countries to limit impacts, we recommend a small carefully-planned workshop to consider marine renewables. This would help to provide advice to countries on how to best mitigate against adverse impacts. Its focus could be a review of pile-driving, but it might also usefully take into account the latest information

about interactions between cetaceans and developments and modelling of potential future activities. A draft workshop agenda is attached here as Annex 2 to assist discussions.

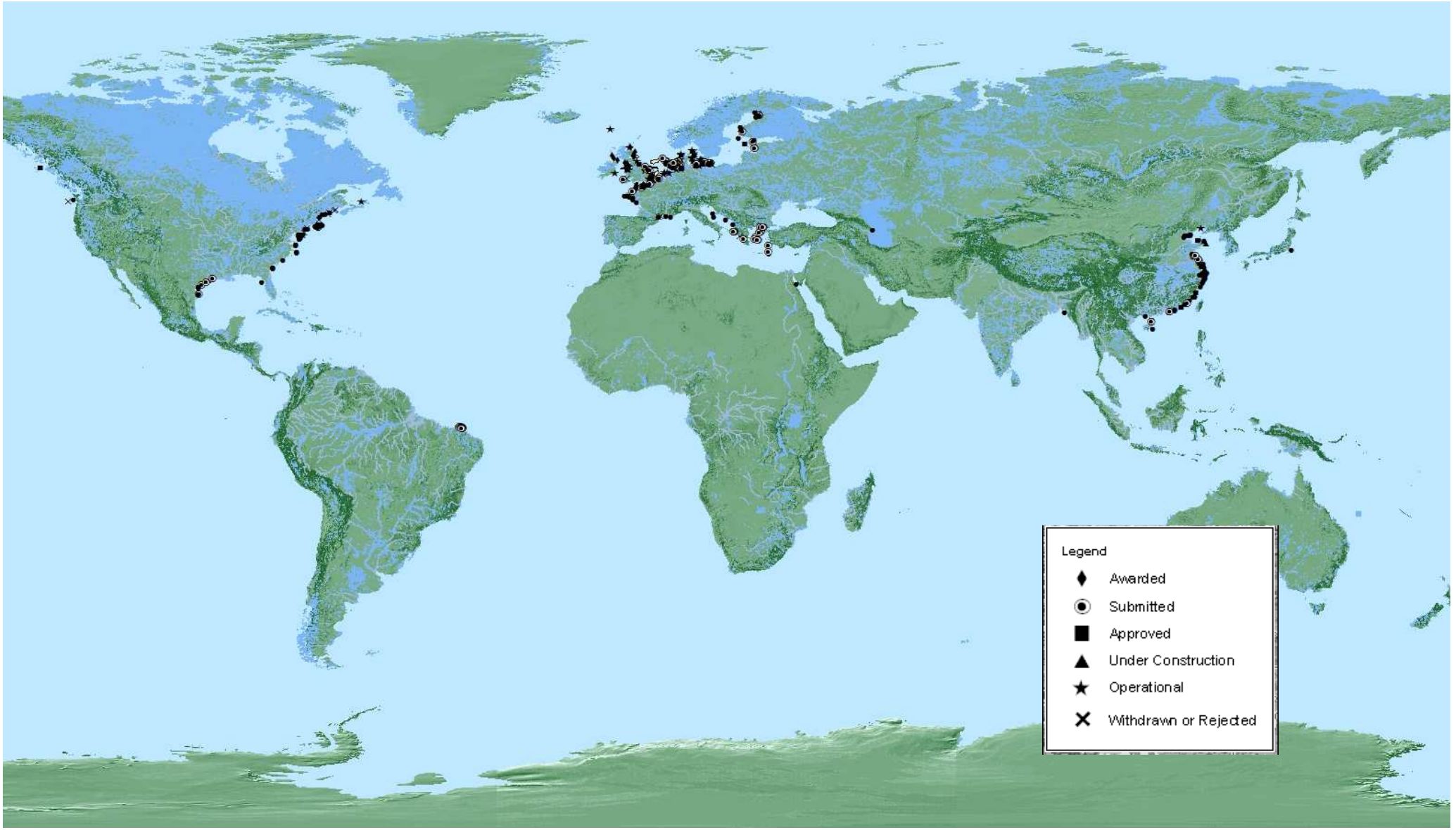
Table 1. Marine wind farms by country

Country	Total No. of Wind farms	No. of Wind Farms by type							Total MW Capacity*	Total Area (km2)*
		Approved	Awarded	Concept/ Early Planning	Operational	Submitted	Under Construction	Withdrawn/ Rejected		
Albania	1			1					539	
Azerbaijan	1			1						
Bangladesh	1			1						
Belgium	10	5		3	1	1			2276	
Brazil	23					23			11,040	
Canada	2	1			1				396	
China	84	4		61	5	8	6		54,694	
Croatia	3			3					840	
Denmark	28	2		7	15			4	3,430.8	769
Egypt	1			1					100	
England	28	9	1		8	5	3	2	10,269.7	35
Estonia	4	1				3			1695	269
Finland	18	2		8	3	3		2	6022	806

Country	Total No. of Wind farms	No. of Wind Farms by type							Total MW Capacity*	Total Area (km2)*
		Approved	Awarded	Concept/ Early Planning	Operational	Submitted	Under Construction	Withdrawn/ Rejected		
France	33	2		23		5	1	2	5886	247
Germany	117	30		17	4	56	2	8	178,941.8	5122
Greece	38			2		31		5	6130	907
Ireland	1				1					
Japan	1			1						
Netherlands	4				4					
Scotland	13		10		1		2			
Sweden	1						1		110	
USA	69	3		52		5		9	29,067	
Wales	3				2			1		

* These data are not available for all wind farms; hence the figures in some of these columns will under-represent the actual figures.

Figure 1: Marine Wind Farms in the Northern Hemisphere



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Simmonds, M.P and Brown, V.C. 2010. Is there a conflict between cetacean conservation and marine renewable-energy developments? *Wildlife Research,* **37** 688-694

ANNEX 1

ICES Recommendations (ICES, 2010): Used with the kind permission of the International Council for the Exploration of the Sea.

RECOMMENDATION	FOR FOLLOW UP BY:
1. With regard to wind farm developments, establishment of means for efficient dissemination of results of common interest and means of making previous EIA reports and previously collected baseline data available for subsequent studies and assessments.	OSPAR, EC, ICES, and respective countries
2. Encourage multinational studies and encourage management decisions regarding offshore wind farms to be based on appropriate populations and/or management units for the relevant marine mammal species, irrespective of national borders.	OSPAR, EC, ICES
3. As the development of offshore wind farms extends further offshore and into new waters, monitoring should be extended to include all commonly occurring marine mammal species and marine mammal species of particular concern.	OSPAR, EC, ICES, and respective countries
4. Geographical location of offshore wind farms should consider the distribution of marine mammals throughout the year, time of day and under typical weather and hydrographical conditions.	OSPAR, EC, ICES, and respective countries
5. Increase efforts to develop common measurement standards for both noise and marine mammal abundance.	OSPAR, EC, ICES
6. Increase the effort to characterize sources of underwater noise related to the construction and operation of offshore wind farms. As part of this, common standards for measurement and characterization of underwater noise should be developed.	OSPAR, EC, ICES
7. Develop methods to assess cumulative effects on marine mammals of the underwater noise level caused by the simultaneous construction and operation at nearby sites.	OSPAR, EC, ICES
8. Step up research on the behaviour of marine mammals as a consequence of increased underwater noise levels, in particular on how changes ultimately affect population parameters.	OSPAR, EC, ICES
9. Increase efforts to characterize fundamental properties of the auditory system of marine mammals and the way noise affects physiology and behaviour.	OSPAR, EC, ICES
10. With regard to marine mammals to work towards common accepted tolerance limits for acute noise exposure and the development of common guidelines for mitigation in relation to pile driving.	OSPAR, EC, ICES
11. To undertake studies to develop better marine mammal acoustic deterrent devices, including realistic trials in the field to demonstrate their effectiveness.	OSPAR, EC, ICES
12. Attention should be given to improve efficient means of real-time detection of marine mammals during pile driving operations.	OSPAR, EC, ICES
13. Undertake other measures to prevent the exposure of marine mammals to high levels of underwater noise. This includes limiting the radiated energy during pile driving and the development of alternative methods for installation.	OSPAR, EC, ICES

Annex 2

Draft Agenda for Future IWC SC Workshop on Interactions between Marine Renewables and Cetaceans Worldwide

1. Overview:

1. Scale of developments in Northern Hemisphere
2. Scale of developments in Southern Hemisphere
3. Definition of necessary baseline data
4. Review of technologies:
   4.1 Energy Generation
   4.2 Anchoring
   4.3 Servicing
   4.4 Decommissioning
   4.5 Cable laying and other
5. Review of available information (including modelling approaches)
   5.1 Interactions with wind farms
   5.2 Interactions with submerged turbines
   5.3 Interactions with other developments
6. Data gaps
7. Recommendations for research, conservation and management.