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From Scotland to New Scotland: Constructing a sectoral marine plan for tidal energy for Nova Scotia

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ABSTRACT

Competing usage of marine space has prompted several coastal nations to implement marine spatial planning (MSP). While progressive governments promote the deployment of renewable energy technologies (RETs) in order to meet renewable energy capacity and greenhouse gas emissions reductions targets, offshore RETs become another player operating within a finite and already stressed marine environment. This paper applies the sectoral MSP process employed by Scotland to the Nova Scotia context in order to draft a MSP for the province's tidal energy sector. Applicable legislation is reviewed in order to establish the regulatory authorities with powers to plan for both the marine development and ecosystem protection agendas. The scoping process identifies suitable resource areas based on the operational parameters of commercially viable tidal current turbines (TCTs), while the sustainability appraisal identifies areas of cultural, industry, ecological, and socioeconomic constraint and exclusion. Plan option areas emanating from the applied methodology demonstrated a 238.345 km^2 (98.1%) increase in suitable TCT deployment area than the marine renewable energy areas identified in Nova Scotia's Marine Renewable Energy Act which did not undertake such a methodology.

1. Introduction

The marine environment has historically played a significant role in sustaining coastal economies, as can be witnessed through the evolution of global super powers from Ancient Greece to the USA. This relationship of societies strategically positioning themselves close to water bodies, thereby proliferating access to the marine environment and its natural resources, continues into modern times, with 44% of the global population living within 150 km of the coast [1]. In 2012, Europe's Blue Economy supported 5.4 million jobs, producing €500 billion [2] through such traditional marine industries such as fishing, shipping, and tourism. Running in unison with this congregation of marine-based economic activity are future projections of global population growth, the majority of which is expected in the 82.3% of coastal mega cities [3], with an increase in living standards expected to accompany such projections [4]. It therefore follows suit that economic activity linked to the marine environment will grow exponentially, providing an increase in spatial usage in finite marine space, which ultimately provides for an increase in the potential for spatial conflict. This dilemma is referred to as user – user conflict [5]. The intensification of various industries operating in marine space, and the subsequent concentration of the extraction of natural resources for purposes of economic exploitation, places stress on the ecological functions of the marine environment, resulting in the declination of the health of the overall ecosystem [6]. This dilemma is referred to as user – environment conflict [5]. Such dilemmas have triggered political support for the application of marine spatial planning (MSP) in order to effectively manage activity in areas experiencing multiple uses. Comprehensive MSPs are being implemented in nations including Germany, Belgium, and Scotland. However, the construction of a comprehensive MSP alone will not suffice as a measure to stabilize marine-based economies. Increases in global warming of 0.65–1.06° from 1880 to 2012 have had substantial implications on the ecological functions of the Earth's oceans at a greater pace than any other in human history [7]. This climate change dilemma has prompted support from all levels of government globally to curtail the release of greenhouse gas (GHG) emissions via the

Abbreviations: **MSP**, Marine Spatial Planning; **TCT**, Tidal Current Turbine; **GHG**, Greenhouse Gas; **RET**, Renewable Energy Technology; **Vmsp**, Mean Spring Peak Tidal Flow Velocity; **SMPTE**, Sectoral Marine Plan For Tidal Energy; **NMP**, National Marine Plan; **LAT**, Lowest Astronomical Tide; **HAT**, Highest Astronomical Tide; **POA**, Plan Option Areas; **MREA**, Marne Renewable Energy Areas; **MRE Act**, Marne Renewable Energy Act; **RLG**, Regional Locational Guidance; **SEA**, Strategic Environmental Assessment; **MEKS**, Mi'kmaq Ecological Knowledge Study; **TZ**, Territorial Zone; **CA**, Competent Authority; **DNR**, Department of Natural Resources Nova Scotia; **DoE**, Department of Energy Nova Scotia; **NSE**, Nova Scotia Department of Environment;; **EA**, Environmental Assessment; **UKC**, Under Keel Clearance; **CVD**, Charted Vertical Depth; **MuZC**, Multiple-Use Zoning Compatibility; **COMFIT**, Community Feed-in Tariff

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promotion of renewable energy technologies (RETs). Given competing uses for terrestrial space in an ever-densifying civilization [3], the deployment of offshore RETs is gaining momentum in the public policy agendas of progressive governments with suitable resources [8].

One such offshore RET that is showing promise with regards to the transition from pre-commercial to commercial status are tidal current turbines (TCTs). TCTs operate to produce electricity by harnessing the kinetic energy from the lateral movement of tidal flows where current speeds reach a mean spring peak velocity (Vmsp) of 1.5 m/s [9]. By harnessing this energy, TCTs become advantageous in comparison to other RETs due to their predictability, reliability, high capacity factors, and ability to easily accommodate energy storage [10], as tidal flows are nearly constant and can be modeled for centuries in advance [11]. Scotland is one such nation that possesses economically viable Vmsps, with available resource estimates demonstrating 32 TW h/yr [12], 25% of Europe's tidal energy resource [13]. Therefore, Scotland has heavily invested in the deployment of TCTs within Scottish waters in order to meet GHG emissions mitigation targets of 42% below 1990 levels by 2020 and 80% below 1990 levels by 2050, while providing 100% of it's electricity demand from renewables by 2020 [14]. However, in attempting to mitigate this climate change dilemma, Scotland recognizes that TCTs essentially become another industry within their national economy that demands usage of marine space. Therefore, anticipating user – user and user – environment conflicts, Scotland has become the first and only nation to construct and implement a sectoral marine plan for tidal energy (SMPTE) to strategically identify suitable sites for TCT deployment, thereby assisting their national marine plan (NMP) in effectively managing industry conflict and ecosystem health while meeting GHG emissions reduction and renewable energy deployment targets [15].

Across the Atlantic Ocean resides another geographical region with substantial tidal current resource potential. The Canadian province of Nova Scotia is home to the highest tidal range fluctuations in the world, measuring in at a maximum of 16 m between lowest (LAT) and highest astronomical tide (HAT) [16], subsequently forcing 160 billion tonnes of water through the Bay of Fundy with every flow of the current, approximately four times more volume that every fresh water river in the world combined [17]. This extreme flow of the tides has been estimated to produce approximately 7.4 GW of power in the Bay of Fundy alone [18]. However, despite substantial provincial and federal investments into the Nova Scotia tidal energy sector, only one TCT is currently deployed in Nova Scotia waters. While industry, government, and R & D organizations have worked in tandem to produce numerous insightful resource, economic, and social studies, the commercial development of the TCT industry remains uncertain. A commonality that the vast majority of European nations who have successfully deployed offshore RETs is the construction and implementation of MSP, although Nova Scotia, moreover Canada, has yet to implement such a plan. This paper constructs a SMPTE for Nova Scotia loosely based on Scotland's SMPTE process. The objective of the paper is to utilize the Scottish methodology and apply it to the Nova Scotia context in order to generate a glimpse into what a SMPTE may look for the province.

The remainder of this paper constructs a SMPTE for the province of Nova Scotia. Nova Scotia's tidal energy industry and the Scottish SMPTE process are discussed in Section 2. The panning process is detailed specific to the Nova Scotia context in Section 3, with outputs generated for each phase of the process. In Section 4, final plan option areas (POAs) are compared to the marine renewable-energy areas (MREAs) legislated in the MRE Act which didn't not undergo a formally structured planning framework. Recommendations are made on gaps in the Nova Scotia context in relation to the TCT development framework currently in place in Section 5. Finally, Section 6 concludes by overviewing the methodology, results, and objectives of the paper.

2. MSP for TCTs

With 7,579kms of coastline [19], Nova Scotia's economy holds strong ties to the marine environment, touting the largest conglomeration of ocean R & D firms in all of North America at approximately 300 [17]. With marine industries accounting for 1/3 of all R & D business in Nova Scotia, the approximately 60 innovator technological organizations generated an estimated over $500,000,000 in revenue in 2009, with projections suggesting an increase in the decades to follow [19]. Nova Scotia is also home to the world's highest tides, the range fluctuations of which result in comparative impressive Vsmps when forced through narrow passages [16]. Such velocities of sites in the Bay of Fundy and the Cape Breton Region have been estimated to produce 7435.8 MW of power, 2096.7 MW of which is deemed sustainably extractable [18]. In order to capitalize upon this vast resource, the Nova Scotia and Canadian governments partly funded the development of a large-scale TCT test center in the Minas Passage called FORCE, which became operational in 2009 [20]. From FORCE's early conception, it hosted an Open Hydro TCT that underwent environmental effects monitoring, although the rotors blew out a few weeks after deployment [21]. Five years later, the installation of four 24.5 kV subsea power cables have made FORCE [22] capable of accommodating four 16 MW TCT arrays, reaching an aggregate installed capacity of 64 MW [17], with projections of 110 MW of electricity becoming online by 2020, accounting for 5% of the current installed electrical capacity, and creating 340 person-years of employment during installation and 550 person-years over the 25-year lifespan of TCTs [23]. An economic assessment undertaken by Pinfold [24] suggests that the tidal energy industry can provide $1.7 billion in GDP [19].

With such a vast resource potential, political backing from the provincial and federal governments, financial support of over $100 million [20], capacity building via the 450 ocean related PhDs [19], supply chain industries amounting in $5 billion in GDP, a world class test facility, regulatory legislation in the Marine Renewable-energy (MRE) Act, and 30,000 direct employment opportunities, Nova Scotia could play an integral role in the emerging tidal energy industry as a global industry cluster, providing physical, technical, and scientific resources to other nations with similar tidal energy potential [25]. Despite such a favourable climate, in 2017, there is only one TCT in provincial waters, the implementation of which was met by intense lobbying by other marine industries over environmental, social, and cultural concerns [26]. However, support for the industry overall does continue in the province. Examining best practices from the international leader in the tidal energy industry in Scotland, the one component that is absent in Nova Scotia is the construction and implementation of a comprehensive SMPTE.

Scotland's SMPTE is subsumed within the offshore wind and marine RET sector identified within the NMP, with all policies and regulations set out in the SMPTE in conformity with the strategic objectives designated within the NMP [14]. The primary output of Scotland's SMPTE is the identification of 10 POAs, based on the prime suitability of commercial-scale TCT deployment at a capacity of = > 30 MW, resulting in a streamlined licensing and consenting regime. Scotland's SMPTE process, (Fig. 1) is comprised of three phases.

The first phase includes scoping for areas with appropriate resource potential and industry, environmental, and social constraint, while regional locational guidance (RLG) from subject matter experts as well pre-statutory consultation with key stakeholders further informs the scoping exercise [14]. The second phase undertakes a sustainability appraisal inclusive of a habitats and regulations appraisal, strategic environmental assessment (SEA), and socio-economic assessment to further inform suitable POAs, which then undergo another round of RLG as well as statutory consultation in order to produce a draft plan. For the final phase, the plan is put forward to Scottish Ministers for adoption, resulting in the provision of licensing for adopted POAs. Given the scope of this paper to construct a SMPTE for Nova Scotia, the