TU Delft

Offshore & Dredging Engineering

**Technische Universiteit Delft**

## A conceptual design of an alternative Ocean Cleanup system

Eight million tons of plastic enters the ocean every year, causing damage to the environment, to human health, and to the economy. Due to rotating currents, called 'Gyres', large quantities of that debris accumulate in five areas around the world. In an attempt to clean up the most polluted area, being the Great Pacific Garbage Patch, Boyan Slat (founder of the Ocean Cleanup) proposed to install a fixed moored, 100km long, v-shaped barrier, to passively catch, concentrate and extract the plastic (Figure 1).

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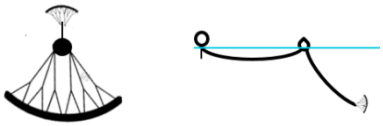
However, from an offshore engineering perspective, it seemed as if there could be cheaper and more efficient alternatives, to achieve the same goal. The research proposal that followed this insight led to the start of this thesis, with the objective of developing a conceptual design, and thereby assessing the feasibility. This objective was accomplished by first analyzing all possible cleaning strategies and strategy specific concepts in a high level and structured process. Using methods such as brainstorming, multi-criteria analysis (MCA), and morphological overviews, strategies and concepts were developed and evaluated. Finally four strategies were proposed, of which a passive concept with sea-anchors, driven by ocean currents, was selected as the most promising strategy (Figure 2). Subsequently, a completely flexible concept which uses hydrodynamic lift to force the barrier open perpendicular to the flow, was selected for feasibility analysis using a numerical model (Figure 3).

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Besides that, an experimental test program was proposed to evaluate another concept which uses a large surface covering membrane.

The feasibility analysis of the concept, was subsequently divided into two steps. The first step focused on the design of a suitable sea-anchor to generate stable lift. For which a three-dimensional model was constructed using a lumped mass approach, in which the system is build-up out of massless springs and all forces are superimposed on the nodes, being; mass, buoyancy, tension, drag, and added-mass. The model was subsequently used to simulate the behavior of a 'Window-shade drogue' (sea-anchor for meteorological research) to partially validate the model. After which the sea-anchor design was adapted to show that stable lift can be generated. Besides this, a one-degree of freedom model gave insight into the parameters required to ensure anchor stability.

The second step focused on the construction and evaluation of a three-dimensional model of the complete concept, and multiple variations. It is shown that the high level selected concept is not feasible, and that the efficiency both in terms of current following capability as in shape retainment, is low. The completely flexible concept is not able to adequately follow a median changing current direction of 16 degrees/hr at 0.17 m/s, leading to entanglement of lines and a collapse of the system.

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Following from these results, a new concept is proposed which requires torsional and bending stiffness to prevent entanglement, and uses a two sided catching mechanism to catch plastic from all directions.

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October 20th, 2016

Sponsor
The Ocean Cleanup

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