Proceedings of The Fifth (2003) Ocean Mining Symposium
Tsukuba, Japan, September 15-19, 2003

ISBN 1-880653-61-3

CONCEPT FOR A WAVE DRIVEN, MECHANICAL ARTIFICIAL UPWELLING DEVICE (M.A.U.D.)

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ABSTRACT

In this paper the authors (two mechanical engineers and one biologist) present the concept of a wave driven Mechanical Artificial Upwelling Device (MAUD-1) to pump deep ocean waters into surface layers and mix it there, thus increasing plankton production and leading ultimately to CO_2 binding, fish stock enhancement, shore protection and water temperature control.

The article describes some of the existing upwelling devices. It outlines the technical principle and gives a conservative performance simulation of MAUD-1. The biological background is presented and the conditions for promising MAUD-1 testing areas are developed. The authors whish to stimulate the discussion among the research community, to increase the interest and chances for the realisation of a first MAUD-1 project in the near future.

Key words: AUMIX, Upwelling, fish production, CO_2 -binding, shore protection, water temperature control.

INTRODUCTION

Upwelling areas (e.g. NW-, SW-Africa, Peru and California) have long been known to be very productive regions in terms of plankton and fish production. Due to wind stress cold, nutrient rich water masses well up into the surface layers which are characterised by sufficient light to enable enhanced primary production. Consequently, phytoplankton and zooplankton biomass increase within a few days or weeks after the upwelling event and can sustain a large stock of fish, birds and larger consumers such as whales, sharks etc.

Within an upwelled body of water successive phenomena can be observed (Herbland, 1973). In the first phase nutrient content is high whereas phytoplankton stock is low. Within a few days phytoplankton increases, nutrients begin to decline and zooplankton shows a slight increase in biomass. Later, maximal values of phytoplankton will be recognised, nutrients are exhausted showing only low levels and the increase of zooplankton biomass accelerates. Due to nutrient limitation, primary production ceases and so does phytoplankton stock. Large amounts of phytoplankton, especially diatoms, sink out of the surface waters at that time, thus leading to a downward flux of organic carbon originally fixed as CO_2 from the atmosphere. Zooplankton biomass reaches its maximum, being now a good pasture for larger consumers, but eventually decreases to levels indistinguishable from that of the surrounding oligotrophic areas.

An artificial upwelling device aim to stimulate these phenomena in regions in which natural upwelling does not occur. The goals of this technical solution can be:

- Increase of plankton production thus leading to higher fish / shellfish harvest with comparatively less variability than in natural upwelling regions.
- Accelerated downward flux of organic matter trapping some CO_2 from anthropogenic input
- Shore protection by partly dissipation of wave energy.
- Temperature control of upper water layers in locally restricted areas

To achieve artificial upwelling, several concepts have been worked out in the past, some of which have matured to the point of prototype testing facilities. These concepts can be categorized according to the driving power, i.e. solar energy, fossil fuels, electrical energy, ocean thermal energy conversion (OTEC), wind energy, wave energy and ocean current induced devices. While fossil fuel and electrically driven versions appear difficult to realize on the open sea (maintenance, energy supply, etc.), the concepts based on OTEC, wind energy or solar energy appear to be very complex and involve high initial investment costs.

EXISTING ARTIFICIAL UPWELLING CONCEPTS AND DEVICES

There are several artificial upwelling concepts based on the use of ocean currents (see patents JP2002306016, JP2001323430, JP10042741, US5267812 and JP2167018). They will not be considered in this article as they require massive civil engineering work, with a major impact on the environment. The authors are sceptical regarding such huge projects as long as the concept of artificial upwelling and its environmental consequences are not understood in full detail. The focus will therefore be on smaller, mechanical and electrical devices.

Solar driven upwelling devices

Japanese scientists have successfully implemented a small photovoltaic driven upwelling device which they called the Density Current Generator (Ouchi, Nakaharama, 1999).