USING FORCED UPWELLING FOR NUTRIENT ENRICHMENT TO INCREASE OCEAN ECOSYSTEM CARRYING CAPACITY.

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With demand for seafood expected to increase dramatically over the next decades, and with supply flat or decreasing from overfishing, multiple interventions are needed to close the supply gap. One promising form of intervention relates to large-scale nutrient enrichment of the upper ocean, either through ocean fertilization, forced upwelling, or other means.

By relying on nutrient enrichment, the natural food chain is enhanced and population increases of wild species may be expected, suggesting higher quality harvested product with premium pricing levels. In addition, nutrient enrichment may provide a naturally more favorable environment for commercial stock enhancement, restocking, and sea ranching.

Large-scale nutrient enrichment may distribute the fish supply across a wider area, leading to increased harvesting costs. But ample infrastructure (fishing boats and gear) is available and could be gainfully employed rather than shut down - the latter being a politically difficult intervention. And, it may be possible for cooperatives and other private sector groups to gain ownership of nutrient-enhanced regions, thus providing economic incentives for sustainable production.

Environmentalists should be in favor of nutrient enrichment since this mimics nature’s best fisheries practices, while reducing many of the environmental and genetic risks they see as inherent to current offshore aquaculture practices.

As one means of achieving nutrient enrichment, we propose a new forced upwelling technology, increasing the carrying capacity of the Exclusive Economic Zone (EEZ) to support more fish and shellfish populations either through natural replenishment, or if appropriate, hatchery release programs. Upwelling is nature’s way of bringing higher-nutrient deep ocean water to the surface to increase phytoplankton growth, which permeates up the food chain ultimately supporting all wild fish species. The beneficial effects of upwelling are seen in the ocean’s once-great fisheries, such as the Grand Banks off Newfoundland, and many others.

Our technology is based on arrays of a wave-driven deep ocean pump design. The pump consists of a buoy connected to a base with valve. A flexible tube conveys deep, nutrient rich water up to just below the surface where it mixes with ambient water. On wave upslopes the valve closes and the entire column of water is elevated; on wave downslopes the valve opens, replenishing the cold, nutrient-rich water inside the base while releasing the higher-nutrient water at the top.

Pumps are tethered one to the next at the base to maintain relative position, and periodically seafloor-anchored to maintain position of the grid. Many thousands of pumps can be deployed efficiently using barges. Pumping rate is a function of tube diameter, wave height and period. Depth can be modified according to the local ocean biochemical profile. The buoys have solar-powered communications and control mechanisms, allowing individual or groups of pumps to be enabled/disabled by remote control using a satellite uplink. This feature will also support sensor data, such as ocean temperature, salinity, pH, and other biochemical measurements. Pump grids would avoid shipping channels, and would not be installed near shore to avoid conflict with recreational boaters.

To implement forced upwelling and provide nutrient enrichment over the entire U.S. west coast EEZ would cost about $5 billion, assuming pump density of 10 per square mile over the 250,000 square mile area from Washington to California (2.5 million pumps @ $2,000 each). In a public-private investment scheme, the government could fund the initial cost and fishing cooperatives could lease long-term rights to production from sections of this EEZ. Over the long term the cooperatives would manage their leased nutrient-enriched fishery for sustainability, paying back government’s initial investment.

We believe the economic benefits of this development would be enormous – creating a new and very substantial offshore fishing industry producing high-value wild species which compete favorably against lower-quality raised fish from foreign fishfarms, while improving our trade deficit, generating a large number of new jobs, reviving the U.S. fishing industry, and reversing the biological decline of the EEZ ocean.

Additional benefits of this technology include absorption of CO_2 to mitigate against global warming caused by burning of carbon fuels. This effect is a natural outcome of the enhanced primary production.