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How eDNA Could be a Cornerstone of the New Blue Economy


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By **Jesse H. Ausubel and Alan Curry** 03-01-2021 03:21:00

A bio-based industry likely to boom soon uses loose DNA in seawater, or environmental DNA, to measure presence and abundance of marine species. Animals in water inevitably shed their eDNA into it.

Surveyors have traditionally monitored sea life by observing seafood markets and trawl nets, diving with goggles, and more recently deploying cameras and sonars.

From microbes to mammals, near shore to mid-ocean, and seafloor to seabirds, humans want and need to know about ocean life. Obvious benefits have derived from more accurate means of locating high-value wild fish for food or for protection in the interests of recreation and conservation. Fishers and dive shop operators may use the same information for opposite purposes.

Blue life has other uses. Fish meal and oil provide feed for other forms of animal life, including carnivorous fishes raised in farms. For thousands of years bones and shells, famously of turtles, became buttons, combs, and other household products. Live animals enter the aquarium trade. Cod liver oil promised good health before the word nutraceutical became popular, and other parts and forms of marine life, including algae, become pharmaceuticals and cosmetics.

Accurate information about the diversity and especially the abundance of marine life obviously has value. But humanity has misjudged abundance and exceeded sustainable exploitation of marine life many times, from abalone and cod to turtles and whales.

Where animals live, their distribution, matters too. Operators of ships want to avoid collisions with marine mammals and areas where they may disturb spawning. Port operators want to dredge at times of acceptable environmental impact. Extractive industries want timely knowledge of their operations, including consequences of spills and accidents. Disposing of wastes (sewage, brines, plastics, and radioactive and other hazardous materials), individuals, companies, and municipalities want to create waste streams harmless to marine animals.

Means of collecting marine biological information are changing, and those entering the field or remaining in it may soon find themselves with a different workload and working environment. What has been a mostly manual undertaking in the salt spray of the field may increasingly resemble space physics, where engineers design and launch probes that feed data to deskbound analysts.

Accordingly, many organizations have begun incorporating eDNA collection and analysis into their oceanographic research, and companies have begun selling eDNA testing as a service. Typically, the customer mails in a filter through which a small quantity of water has been passed, DNA is then extracted from sediment on the filter, and the DNA is then sequenced and analyzed with bioinformatics. DNA identifications are based on existing reference sequences (such as those of the mitochondrial 12S rRNA gene) in the open public database GenBank. In the continental US exclusive economic zone, good coverage (>80 percent) of resident fish and marine mammals makes this process straightforward.

eDNA collection can quickly identify a single species of interest (such as a marketable fish or an invasive species) or search for a class of life (such as sharks or marine mammals). The DNA in one liter of water contains about the same amount of information about diversity and abundance of the life in that water during the past day or so as 66 million liters filtered by a trawl net, the volume of a football stadium to the top of the goal posts. In comparisons, eDNA captured 90 percent of the species netted by a trawl and detected more unique species than the paired trawls. eDNA also ranks abundance similarly well.

Significant opportunities exist immediately to augment trawls with eDNA sampling, including when trawls are cancelled or reduced owing to storms, equipment failures, costs, or crises such as COVID-19. eDNA promises great temporal resolution and precision due to the short time and therefore short distance over which shed DNA is thought to degrade, and due to the detection of DNA from fish that would slip through or otherwise evade a trawl net.

Work underway will clarify how near to one another in space and time water samples must be taken to characterize accurately a given surface area or parcel of ocean—at least comparably to trawls or sufficient to satisfy reporting regulations as currently worded. Trawls have a very high throughput of water and must actually catch the fish; eDNA must simply capture the shed genetic material trailing a fish or school of fish.

Priorities to realize the potential of eDNA for the New Blue Economy include; further building the reference library of DNA sequences of marine species; developing the technology of remote sampling (such as drone and marine robots that could collect and filter water, and save the filters); integrating, and speeding and lowering the cost, of automated processing of samples (for example, development of a single "machine" that could trap sediment containing DNA, extract the DNA from the sample, do the further steps such as sequencing, and then email the sequence file to the user); improving bioinformatics for analysis and visualization of eDNA data and developing sites or enterprises that would aggregate and store eDNA information and results so that these could be integrated to reveal larger patterns over space and time.

While eDNA research has advanced rapidly over the past decade, eDNA is in its infancy as a tool for regulators and commercial entities of the New Blue Economy. Its value-proposition (efficiency plus precision) awaits regulatory validation and broad commercial endorsement.

Companies could cater to monitoring needs with relatively localized operations at sea ("genomic weather stations"), and perhaps even provide basin-scale (eventually global-scale) maps and databases with near real time updates of the presence and abundance of key marine species of scientific, ecological, and commercial value. New government regulations must explicitly allow or require eDNA monitoring (vs. trawling) or establish that the two methods are comparable in the context of environmental impact submissions.

Monitoring the location and movement of marine wildlife has been cumbersome and costly. The advent of techniques to isolate, amplify, and analyze eDNA can reduce the cost in time and money for oil and gas operators to monitor their operations, port operators to dredge, fisheries to open and close, coastal developers to assure the public that their works operate responsibly, researchers to explore and track biological changes, and governments to nominate areas for protection and restoration and to evaluate their success.

eDNA and companion developments in genomics can transform biological information for microbes to mammals, near shore to mid-ocean, and seafloor to sea birds. Combined with advances in tagging and tracking and in acoustics, we can foresee during the "Ocean Decade" of the 2020s more reliable, comprehensive, and timely biological information. The key is not expensive platforms, but genomics, autonomy, sensors, analytics, and the other technologies that characterize the emergent New Blue Economy.

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