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HIGH RESOLUTION IMAGING OF SEA-BOTTOM, WHAT THE EYE DOESN'T SEE, THE HEART DOESN'T GRIEVE OVER

Objective of this article is to emphasise importance of work of inventors and scientists that work on development of tools (sonars) that allows for imaging features of water space that is invisible for human senses. The article indicate extent of damage of sea-bottom environment resulting from fishing activity. This activity performed for centuries results in substantial reduction of valuable biological productivity of Batlic Sea waters. The reason was lack of means that allows for easy look into the depths. One of the tool that can be used to evaluate this activity in real time, is hydroacoustic imaging using scanning sonars and multibeam echosounders. Acoustic imaging methods were already utilized to indicate the extent of damage to bottom habitats. Particular areas of the bottom are archeological sites (wrecks) that "document" damage done by fishing and mooring activity and to study influence of this activity on sea bottom environment. Results of these studies give impressive information regarding scale of possible influence of fishing activity on sea bottom and its biological conditions as well as real reason for the "overfishing". They also indicate importance of bottom related environmental issues during current and planned extensive offshore activities such as deep sea nodule mining.

INTRODUCTION

While looking from a beach perspective, marine environment seem to be endless and sustainable. It is due to optical phenomena at the water surface like ray reflection, As result, we are not able penetrate the depth with our senses. Momentary appearance of water body depends on weather but finally waved or calm water surface seems always the same and self-healing. This is the reason while people consider the ocean as unlimited source of wealth and unlimited sink for all anthropogenic wastes.

The direct reason for this paper was appearance of the photograph of nesting grounds of Jonah's icefish (*Neopagetopsis ionah*) discovered recently under sea cover of Weddell Sea. This colony of icefish is the largest found to date, stretching across more than 150 miles (240km) of the seabed. The sheer size of the colony 60-million-nests suggests the whole Weddell Sea ecosystem is influenced by these nests. The images show active fish parents that bild nest and take care for their roe. At the same time the author was investigating means of detailed imaging of sea-bottom features. Studies of old wrecks are examples of such activity. Example images of such sites (fig. 4) are really horrifying while put aside to images of Jonah's icefish nesting grounds. Without explanation it is difficult to guess what we see on the fig. 2. I fact it is side scan image of the wreck site. Parallel lines on the image illustrate extent of local fishing activity and magnitude of physical influence to sea bottom caused by this activity. Simply say-

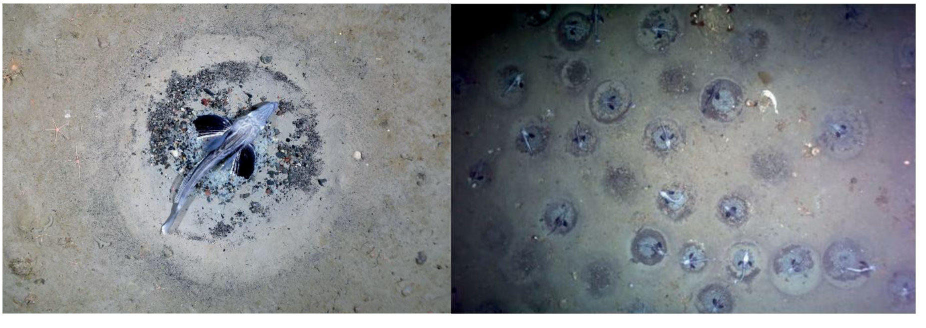

Fig. 1. Photograph of nesting grounds of Jonah's icefish (*Neopagetopsis ionah*) discovered under sea cover of Weddell Sea Alfred Wegener Institute January 14, 2022. (https://scitechdaily.com/spectacular-discovery-in-antarctica-massive-icefish-breeding-colony-with-60-million-nests/)

Fig. 2. Left: A species of cnidarian in the genus Relicanthus with 8-foot long tentacles attached to a dead sponge stalk on a nodule in the eastern Clarion-Clipperton Zone. These are closely related to anemones [1],
Right: Sea bottom covered by manganese modules and invisible layers of bacteria appears as life-less gravel Location: At the Godzilla Mullion in the Parece Vela Basin May 16, 2009 [https://www.jamstec.go.jp/gallery/e/geology/resource/003.html] .

ing, the bottom was deeply ploughed. One can guess the image of nesting grounds of Jonah's icefish if they would not be protected by thick ice. While archeological sites are not usually protected by thick ice cover, they are exposed to damage by fishing activity. In fact majority of sites are badly damaged. Substantial part of human heritage was destroyed this way already. However after being discovered, wreckage remaining are usually studied for many years ad offer quantitative information regarding processes of destruction of both archeological artifacts and surrounding environment.

WHAT IS TECHNOLOGY OF INDUSTRIAL FISHING

Till quite recently the author awareness of industrial fishing technology can be imagined by a trawling net suspended in water space that catches schools of fish possibly detected by trawler's sonar. It is true in some cases, but reality is much more complicated. The list of "fishing" technologies and tools is very long and includes several real strange devices. It starts with bottom trawls illustrated on fig 4 but includes scallop drags that can be seen on fig. 6, left. The dredges consist of a triangular frame, about 750mm wide, with a toothed bar at the front to flip the scallops out of the seabed and into a collecting bag behind it. This bag is made of chain links forming a chain mesh on the bottom and usually netting on the top. **Several** of these dredges are towed behind a heavy spreading bar, usually one from each side of the vessel. The length of bar and number of dredges is dictated by the power of the vessel and its length of side deck to work the dredges over. The number can vary from 3 or 4 on a small 10m boat up to 18-20 on a 30m vessel with 1500hp engine. It is apparent that fish nesting grounds after fishing for scallops look as can be seen on fig. 6, right. Simply nothing is left intact.

Use of heavy beams to facilitate fishing activity in European waters was confirmed for at least nine century. Environmental awareness of the potentially destructive power of fishing technologies on the marine environment is a centuries-old dilemma. As early as 1376 a

Commons Petition to King Edward III of England complained about a newly introduced fishing gear, the ‘wondyrechoun’, a “three fathoms long and ten of men’s feet wide” state-of-the-art device[3].

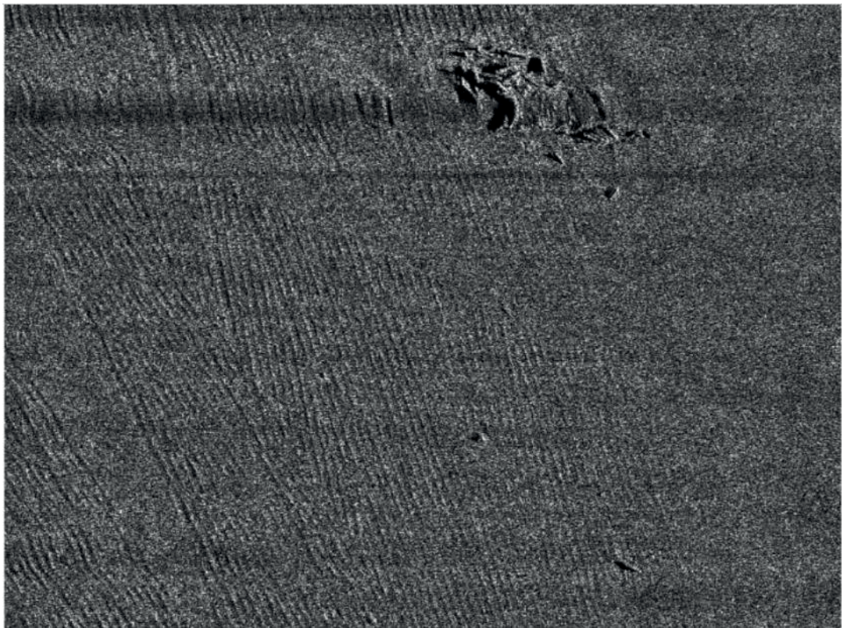

Fig. 3. A side-scan sonar image in the Western Approaches to the English Channel showing furrow lines cut by a scallop dredge boat through a rare shipwreck of c. 1670-90 (Odyssey site 35F). At a depth of 110m,[2]

Fig. 4. A ceramic cargo fallen on one side on a mid to late 19th-centurywooden shipwreck (Site 2T11w24b-1; Target 581). The top edges of the plates have been 'shaved' by a trawler/dredge. Atlas shipwreck survey zone, depth 124.0m.[3]

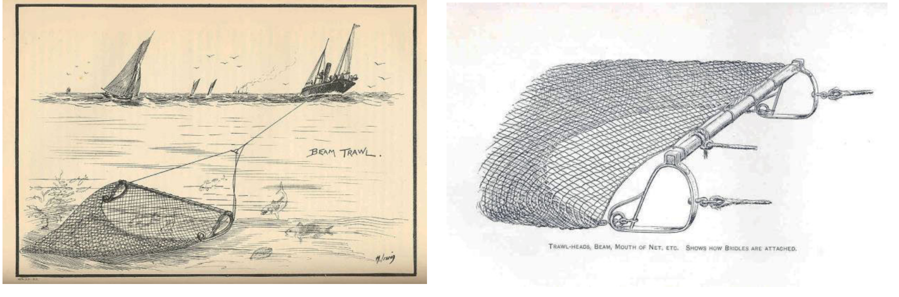

Fig. 5. Bottom beam trawling by sailing trawler around year 1850[4].
Till year 1980 weight of the trawling gear increased to 30 tons[5] .

Fig. 6. Left: A scallop dredge [6], Right: Result of application of a scallop dredge to bottom environment [7],

"made in the manner of an oyster dredge… upon which instrument is attached a net so close meshed that no fish be it ever so small which enters therein can escape… the great and long iron of the wondyrechoun runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below water there… the fishermen take such quantity of small fish that they do not know what to do with them; and that they feed and fat their pigs with them, to the great damage of the commons of the realm and the destruction of the fisheries, and they pray for a remedy" (Alward, 1932: xx).

Since development of effective fishing gears and steam powered vessels in nineteen century we face so called "overfishing". It "industrial" fishing developed slowly from 100 000 tons and finally ended at 80 mln tons annual catch. Significant collapse of robbery was inevitable. It is sometimes assumed that introduction local catch quotas is enough to re-build productivity of the fishing ground. While considered extent of damage caused by tens of years of ploughing the bottom there is probably no return to virgin conditions. At least not in short period of time. It is possibly the case of Baltic Sea where this is not really helping. This is because the bottom habitat may not be renovated this way. Knowing extent and longevity of fishing operations on European waters we can easy assume that no one really knows original nestling behaviour of various fish species, that used to live on undisturbed bottom. Unknown mechanically damaged (levelled) bottom features and appreciated by different local species need to be recreated and re-populated by sea-creatures already ceased to exist.

SEA BOTTOM MINING FOR METALS

New potential area of marine large scale industrial activity and appropriately large scale damage to environment, is sea bottom mining or minerals. There are various minerals of interest like metal reach crusts and phosphates. However the most representative to the problem and most abundant are manganese nodules. They cover vast areas of ocean bottom with density of up to 20 kg per square metre. Since sixties of last century they are considered to be "readily available and unlimited" source of more or less strategic metals. Area of the Clarion-Clipperton Zone, currently under jurisdiction of International Seabed Authority, is mostly considered and prepared for exploitation. It is deep-water plain wider than the continental United States. Should commercial deep-sea mining take place, the controversy over its environmental impacts may be just the beginning. While the ISA's principle of common heritage has legal force, the practical realities of sharing the financial proceeds and environmental issues are not clear. When the Mining Code is approved, more than a dozen contractors could begin commercial extraction there. And there is no legal means to stop this activity.

What would be the ecological consequences of future mining for polymetallic nodules in the deep sea in not really known. Phenomena such as sediment mixing, removal of nodules and sediment plumes that extend influence of activity several kilometre are considered to be of most importance. Some studies are under way in the framework of the European project "Ecological Aspects of Deep-Sea Mining". Scientists from Germany and other European countries have revisited a disturbance experiment conducted 26 years ago in more than 4,000 meter water depth in the eastern equatorial Pacific. They report "that even bacterial activity is still low in the plough tracks"[8].

Despite the great potential for the global metals market, polymetallic nodules remain a great promise. However, the situation may change quickly if the supply of raw materials from land deposits is not able to meet the growing demand. In order to be able to join the international division of labor in this field, it is necessary to constantly analyze the state of the art, define and prepare proposals for solutions. In fact, some 30 years ago, Gdansk University of Technology developed a concept of the mining system for industrial recovery of 5 mln tons of, so called, "wet nodules" annually [9]. The mining complex concept was prepared for the Interoceanmetal organization. It differs from the most frequently considered technologies that use pumping for vertical transport (recovery from depth) of nodules. Large, autonomous, vehicles were intended for collection and vertical transport of nodules. It also adopted a somewhat controversial concept of release of solid ballast to balance the weight of nodules and to propel the vehicle.

he system (while build) would yield 100 000 tons of strategic metals annually at cost of annual destruction of 500 km^2 of sea-bottom and destruction of 10 000 km^2 during 20 years of planned operation. Specific positive aspect of proposal presented by Gdansk University of Technology was idea to replace nodules with solid state ballast (rocks) that would replace nodules as supports for living creatures that require such bases to fix and grow.

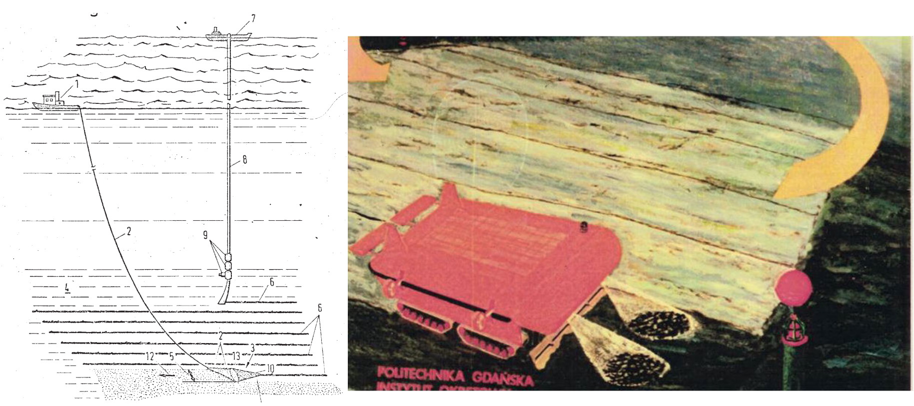

Fig. 7. Proposals of manganese nodule mining systems that will cause sea bottom damage and images of this damage similar to that of resulting from bottom fishing with use of contact gears.

HIGH RESOLUTION IMAGING AS A TOOL FOR LARGE SCALE DOCUMENTATION OF CHANGES OF SEA BOTTOM STRUCTURE

It is opportunity to pay tribute to the persons that developed the technology of hydroacoustic and made it available to investigators of environment before bottom habitat is damaged beyond ability of recovery. To make society aware of consequence of industrial activity, is compulsory to illustrate processes and their results, providing citizens with pictures that are easy to understand. Photographic technology was used and can be used for this purpose. This is excellent tool to visualize local phenomena like damages shown on fig. 3 and fig. 5. However, but it is difficult to use photography to document processes that take place on vast areas such as “fishing grounds”. Laser scanners can improve imaging processes in specific circumstances (for example in shallow waters), but hydroacoustic imaging gives best results since many years both in achieved resolution and productivity (area imagined in unit of time). Hydroacoustic imaging of water space started with use echosounder like transducer mounted on side of a ship. First side scanning sonars were transmitting conical beams and were able to show silhouette of a submarine. First side scan imaging sonar on towed body was developed in year 1950 as military equipment. Its commercial version was fielded in year1960. Up until the mid-1980s, commercial side scan images were produced on paper records. The present day these systems, military and commercial, have been augmented by developments in swath bathymetry, multi-beam echo sounders, and synthetic aperture sonars (SAS) 1970 and various advances in signal processing.

Best tool to be used to document subtle features on wide areas seems to be high frequency side scanning sonars (SSS) and more advanced version of this technology, synthetic aperture sonars (SAS) with adequate gap fillers. Both types SSS and SAA sonars offer resolution of 30 x 30 mm. However, synthetic aperture systems offer up to 5 time higher imaging rate at similarly higher equipment cost. Due to much lower operational cost (short time required to scan the same area) the SAS solution is very favourable imaging of for large areas. For shallow, low turbid waters it wise to consider laser scanners (LIDARs) that provide centimetre resolution up to 25 water depth.

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