

MARINE GROWTH ON NORTH SEA OIL AND GAS PLATFORMS

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INTRODUCTION

In the last decade the development of Britain's North Sea oil and gas resources has seen a dramatic increase in the number and scale of offshore platforms, from the first gas platforms off the East Anglian coast, in less than 30m of water, to the very large structures in the East Shetland basin in more than 200m of water. By 1981 more than 100 platforms will be in position and according to industry predictions will be present for at least thirty years, although this is probably an underestimate. Until recently marine biologists appear to have shown little interest in these structures and the biological opportunities they offer. However, since 1974, the Offshore Installations (Construction and Survey) Regulations have meant that there is a legislative requirement on each operator to report on the thickness and extent of marine growth on each installation as part of the recertification requirement. Such reports are to satisfy the recertification authorities that the growth on any platform does not exceed the growth tolerance limits designed into the structure : however, more and more engineers in industry are becoming aware of the value of having more marine biological information than levels of percentage cover and thickness of marine growth at different depths. Probably the most important consequence of marine growth is the increase in structural loading that it produces. The increase in gravity loading is unlikely to be a problem as the specific gravity of most types of growth is close to that of seawater; it is the increase in the sectional area of structural members resulting in an increased resistance to waves and currents that is the most important aspect of growth on platforms. On one North Sea platform the build-up of marine growth has implicated in the fatigue failure of a diagonal bracing system : marine growth had increased the diameter of the bracing tubes from 300mm to 700mm. Marine growth is regularly cleaned, at considerable expense, from gas platforms in the southern North Sea. In the deeper waters of the central and northern Sea sectors, platforms are much larger and can accept higher levels of marine growth. Most platforms in these areas have not yet been in place long enough for marine growth to increase to levels that require cleaning but for some platforms such levels may be reached in the next year or two. Marine biologists have a useful role to play in predicting the rate of growth of the different species present so that engineers can assess future cleaning requirements.

Marine growth, by its very presence, interferes with visual inspection of key areas on a platform, for example, the condition of welds around nodes. This has important economic consequences. During a weld inspection a diver will generally spend far longer removing an obscuring layer of marine growth than the time involved doing the actual inspection: a cleaning to inspection time ratio of 4:1 is not uncommon. This becomes expensive in the saturation diving range, below 50m, and of the £2.9m spent on cleaning in 1977, £2.1m was spent on saturation diving. It has been forecast that by 1985 total cleaning costs will have risen to £17.3m.

A great deal of attention is being paid to the problems of corrosion of offshore structures and among other things, the relationships between marine growth and corrosion is poorly understood. At the present time there are two conflicting views. One is that a layer of marine growth protects a steel surface by reducing the water flow past the surface; the other is that beneath the marine growth suitable conditions exist for the development of micro-organisms capable of encouraging corrosion, especially sulphate-reducing bacteria (SRB's). Decomposing marine growth may also produce acidic decay products which directly attack the structure. The area is one where there must be sensible cooperation and coordination between marine biologists and corrosion engineers and this is beginning to develop. Marine growth can also settle on the sacrificial anodes, usually of zinc, magnesium or aluminium, that are essential parts of cathodic protection systems. Sacrificial anodes are designed to corrode preferentially to the steel of the structure and it is unclear at present just how a layer of marine growth alters their performance.

Over the last two years there has been an interest shown by the Department of Energy in marine growth on oil platforms. The report by Freeman (1977) was the first definition of the problem and included a call for better prediction by marine biologists. Since then a number of university groups and private contractors have been sponsored to investigate the problem. Although there is a sound engineering requirement for the information there is a significant amount of "pure" marine biological information to be obtained. Apart from data on the distribution and growth rates of individual species, the opportunity exists to investigate the succession of different fouling communities with time, a subject that has received considerable attention recently, the paper by Connell and Slatyer (1977) giving a review of the recent literature. Each platform represents a surface placed at known time in the sea and the pattern of settlement of marine organisms and subsequent changes in community structure can be followed. There are problems in obtaining this information. Oil companies operate in the commercial world and have to be convinced of the value of dedicating expensive diving time to collecting information about marine growth which may be more than they need for their own immediate purposes. In addition, there are problems of commercial confidentiality. This has to be overcome by convincing operators of the advantages to be gained by a pooling of information from as many fields as possible so that data on growth rates and community changes from one area can be applied to other areas.

The Zoology Department at Aberdeen University has established an Offshore Marine Studies Unit to work on a consultancy basis for the offshore industry and this group is funded by the Marine Technology Directorate of the Science Research Council. The aim is to establish a central data-bank to collate and coordinate marine biological information from as many fields as possible and to provide interested workers in other universities and research institutions with material for their own research interests.

METHODS

Because of the hazardous nature of offshore diving in the North Sea there is no question of marine biologists themselves diving around North Sea platforms. Information has to be collected through the commercial diving companies that carry out inspection, repair and maintenance work for the oil companies. The Offshore Marine Studies Unit has developed a standard marine growth inspection procedure designed to obtain the maximum amount of information at minimum cost. The procedure involves the establishment of a number of inspection sites on a platform each of which is accurately located to enable re-identification in later inspections. Photographs are taken at each site, a set from 1.5 to 2m away from the structure and another set .10 to .15m from its surface. Photographic methods differ between diving companies but high quality colour photographs are obtainable that allow identification to species level for many organisms. At the same site the marine growth from a 15x15cm square is scraped into a polythene container. In addition to this divers make a visual inspection of the marine growth in the area and report on the thickness of the cover and the presence of the dominant species. This information is collected through voice-link by the diving supervisor and recorded on a standard card. The data is collated and used to produce a description of the overall fouling pattern of the jacket and, in addition, the examination of the same inspection sites over a number of years will enable any changes in the fouling pattern to be accurately monitored and eventually predicted.

RESULTS

At the present time the problems of commercial confidentiality make it impossible to describe in detail the results gathered sofar but some general observations can be made to show the scope of the work and the kind of information that can be obtained. The platforms that have been examined in most detail to date are in the southern North Sea, in BP's West Sole gas field and in BP's Forties Field in the central sector of the North Sea.

In 1977 BP decided to remove an unmanned satellite gas platform in the West Sole field. The jacket was removed in one piece and taken to the Highland Fabricators Yard at Nigg where it was examined by corrosion and structural engineers. The Offshore Marine Studies Unit was contracted to produce a report on the marine growth on the structure. The WE platform was only fifty miles from the coast and surrounded by English coastal water. Different parts of the structure had been cleaned at approximately two yearly intervals so there was no useful information to be gathered on successional changes that might have taken place in the ten year life of the structure. The depth from the splash zone to the mudline was 24m.

The most striking feature of the marine growth on the platform was the well defined zonation. From the surface down to a depth of approximately 12m there was a zone in which mussels and hydroids were abundant. The mussel Mytilus edulis dominated the area but in between clumps of mussels and growing on the mussels themselves was the hydroid Tubularia sp. Close to the steel surface beneath the mussels and the hydroids was a "detrital turf" inhabited by very large numbers of the amphipod Jassa falcata. From the base of the mussel zone down to a depth of 19m there was a zone dominated by the anemone Metridium senile which in many places formed a continuous cover over several square meters. Finally there was a narrow zone from -19m down to the mudline which was dominated by barnacles and hydroids. This zone was the most diverse; Balanus crenatus was the commonest organism followed by Tubularia sp. and small colonies of Alcyonium digitatum and Halichondria panicea.

It is notable that this broad distribution pattern is almost identical to that described on two platforms in California. The platforms Hilda and Hazel are in the Santa Barbara Channel in 30m of water and have been the subject of a detailed ecological survey (Mearns, Moore & Bascom, 1975). The presence of large numbers of the starfish Pisaster ochraceus on the seabed around the platforms has prompted work on the possibility of biological control of mussel fouling on the platforms. The mussels, Mytilus californius, can grow to a length of .25m and when present in large numbers on the upper legs and crossmembers of the platforms can cause a significant increase in loading; they are periodically removed by divers at considerable expense. Pisaster is a natural predator of Mytilus but is prevented from climbing up the platform legs to the mussels by the presence of the continuous band of anemones, both Metridium senile and Epiactis prolifera. Chevron, the operators of the platform, are sponsoring field work on the movement of starfish up the platform legs once the band of anemones has been removed. By marking individual starfish with latex injections it is known that individual Pisaster can climb up to the surface levels within 24 hours of anemone removal. The rationale of the work is that it may be less expensive for divers to remove anemones, a task that is easier than removing mussels, so that starfish can climb up and predate on the mussels. The work at present is assessing just how effective starfish predation is in removing significant amounts of mussels. Similar work is beginning in the West Sole field to see if a similar form of biological control can be established. Videotape of the seabed around the West Sole platforms has shown that large numbers of Asterias rubens are present, presumably attracted to the mussels that are cleaned from the platforms but may also be dislodged by storms.

The Forties Field is in the central sector of the North Sea in a water depth of 110 to 135m. There are four platforms installed between 1975 and 1977. Marine growth inspections have been part of the overall inspection procedures for three years and this has been long enough to observe some successional changes. Once again, for reasons of commercial confidentiality, it is not possible to report on the results in detail here, but some general observations can be made. As in the West Sole field, the mussel Mytilus edulis and the hydroid Tubularia larynx dominate the surface zone to a depth of approximately 25m. This community has been present since soon after the platforms were installed and will probably remain the dominant community in this depth range. Below approximately 25m there has been a change in the fouling community in the three years that we have been examining the fauna. There is a very distinct initial colonising community that can produce an almost 100% cover in the first year over the depth range from 25 to 75m.

The species in the community are almost all solitary and nearly all have calcareous tubes or shells. The tubeworms Pomatoceros triqueter, Hydroides norvegica and Serpula vermicularis are all very common with Pomatoceros being the most abundant. The saddle oysters Anomia ephippium and Monia squama are also very common. From information collected in succeeding years it is clear that the initial colonisers are gradually being overgrown and smothered by a more complex community of organisms, the dominant members of which are colonial. Many hydroids are present, the commonest being Tubularia larynx, Garveia nutans and Bimeria vestita. There are several bryozoans with Alcyonidium parasiticum being the most common. Among the tunicates the colonial Diplostoma listerianum and the solitary Ascidiella scabra are common, as is the anthozoan Alcyonium digitatum. The anemone Metridium senile, that is so common on the West Sole platforms and produces almost continuous cover over about one third of the depth profile there, is also common on the Forties platforms. It does not dominate the midwater zone as completely as in the West Sole field but in places there is continuous cover of several square meters in extent and it

remains to be seen if this will be increased in the face of competition from a larger number of other species. The tendency for colonial organisms to outcompete solitary forms in epibenthic communities has been commented on by Osman (1977).

Below 75m the amount of marine growth begins to decline but there are two species that are very common. The colonial tubeworm Filograna implexa has a cosmopolitan distribution from the North Atlantic to the Red Sea. It occurs extensively in British waters from Shetland to the Channel Islands. Because it is most abundant and grows to a large size in deeper, calm water it is not commonly met with. It is extremely common on all four Forties platforms and on other platforms we have examined in the northern North Sea. Between 75m and 100m it is the dominant species and forms numerous colonies up to 1m in diameter and .4m in thickness. In places, individual colonies begin to grow together to produce reef-like sheets of cover. The other common deepwater species is the barnacle Balanus hameri. This is a species found only in deep, cold water and is restricted to northern temperate latitudes. As with Filograna, there are places on the Forties platforms where Balanus hameri is abundant enough to produce continuous cover. The maximum recorded size for this species is a basal diameter of 5cm and a height of 8cm. Some individuals on the Forties platforms are close to the recorded maximum size with a maximum possible age of only three years. This is an example of the way in which information gathered from oil platforms for an industrial requirement can provide data on factors such as growth rate, maximum size, and longevity for many species. It is remarkable that for many of even the commonest British marine invertebrates there is little information on much other than distribution. Now that reference sites are established on oil platforms it will be possible to return in succeeding years to photograph particular organisms and colonies, providing valuable information on their individual growth rates and competitive interactions.

CONCLUSIONS

The placing of oil and gas platforms in the North Sea in accurately known positions and known times provides a remarkable opportunity to examine patterns of settlement and succession in epifaunal communities. The information can only be gathered with the active goodwill of the oil companies and it is unfortunate that marine biologists and biologists in general have a poor image with oil companies, arising from some of the more sensational claims of ecological damage reported by biologists and "environmentalists" in the popular media. There are many ways in which marine biologists can provide useful information to operators and this is beginning to be realised by both sides. At present there are problems involved in the free dispersal of information in the scientific literature but with time this can be overcome.

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ROLES OF INTERSPECIFIC AND INTRASPECIFIC COMPETITION IN CORAL ZONATION

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Early work on coral zonation was concerned largely with the reef flat (1, 2) though reef slope zonations are being increasingly reported (3-6). In most studies the causes of zonation are primarily attributed to abiotic factors such as light and exposure (7, 8) and only rarely have biotic effects (9) been suggested as contributing factors. Studies of coral populations and zones on Chagos reefs indicate that certain biotic factors may be of considerable importance in causing and maintaining zones and these include interspecific aggression and intraspecific competition.

A study of interspecific aggression has shown that most species which exist in dense zones with nearly monospecific canopies are aggressive, or capable of digesting or otherwise killing neighbouring colonies of most other species (10). Also, population studies of these zone-forming species (11) have shown that within each zone strong intraspecific competition exists amongst the individuals of a canopy species. This is evidenced by bimodal size-frequency population structures where young are retarded until an opportunity such as a gap in the canopy permits accelerated growth into the adult phase. Very often the zones in which these events occur show abrupt boundaries.

This paper outlines the possible contribution of interspecific and intra-specific competition to the maintenance and stability of coral zones. A quantitative assessment of the depth range of several zones is made and related to the total depth range of the species.

Several transects were examined on seaward and lagoon slopes of Peros Banhos and Salomon atolls, northern Chagos. On each, total depth ranges of species were obtained by detailed searches and collections at intervals of 3 or 6m to 45m or to the lagoon floor. For zone determination a rope marked at 0.5m intervals was laid up each slope either from 40m or from soft substrate. The depth and identity of the coral or other substrate touching or lying vertically beneath each mark was recorded. Records were divided into 3m depth spans.

Figures 1 and 2 depict transects from several seaward and lagoonal slopes respectively. In all cases the transects have a similar substrate throughout which is itself unlikely to affect zonation. Thick bars indicate a cover of 50-100%, thin bars 10-49%. If a species shows such a distribution it is deemed to form a zone. If the species occupies a greater depth range than is covered by these, the extent of this is shown by a broken line.

Considerable similarity exists between transects within each type of reef slope. On seaward reefs (Fig. 1) five transects each show three zones of similar species and sequence, and although their depth spans vary they are centered at similar depths. One exception exists (No. 6) which had two zones of different species. Three lagoonal categories exist (Fig. 2);