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Marine environmental issues of deep-sea exploration and exploitation activities (oil and gas) off the coast of Israel

Survey of fouling aboard ‘ATWOOD BEACON’
Limassol, Cyprus, 25 October 2012

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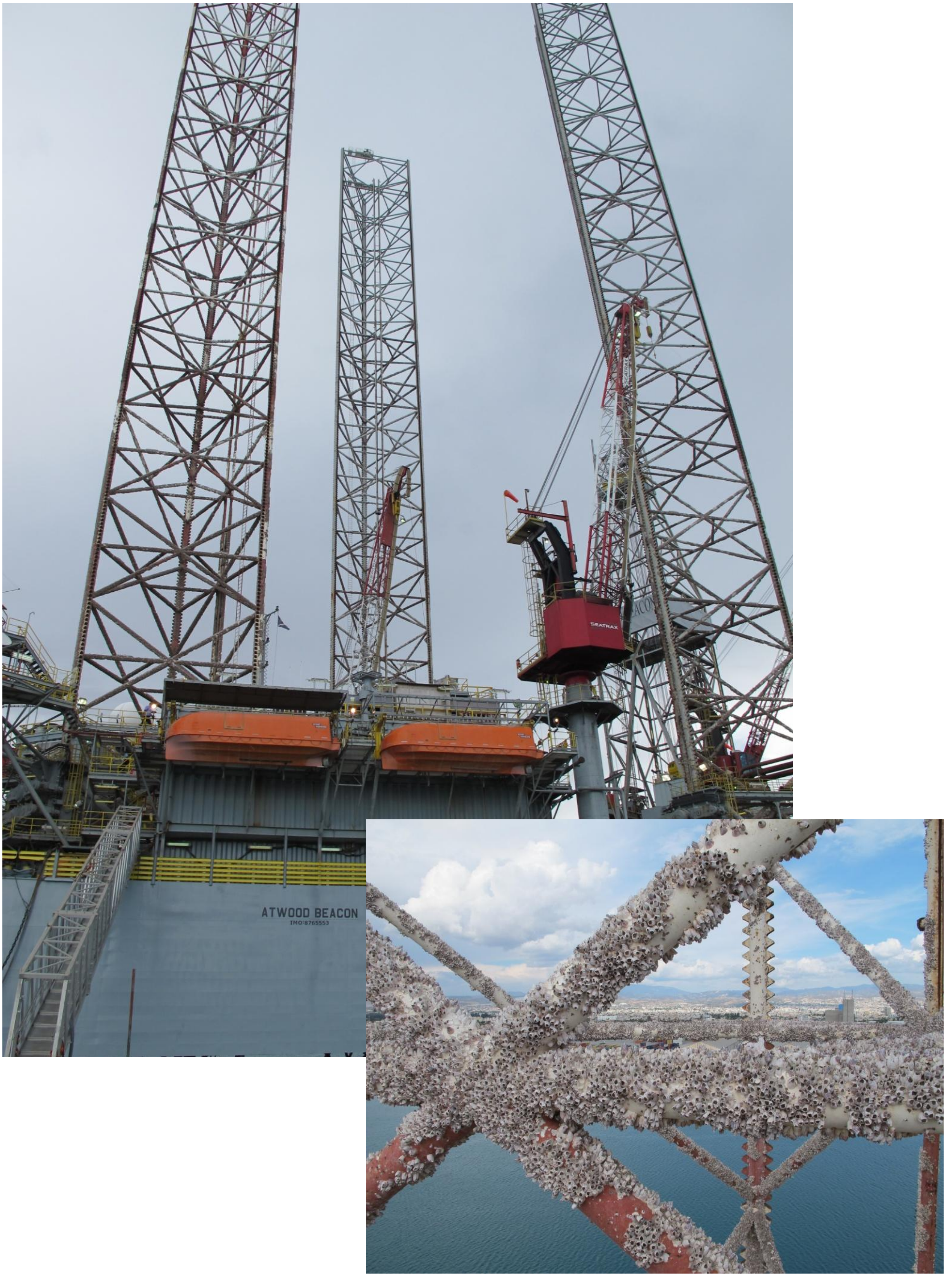
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Introduction

Biological invasions resulting in the establishment of species introduced beyond their native geographic range are altering marine ecosystems worldwide and their adverse ecological and economic impacts are increasing. There is growing concern over the reported increase in non-indigenous species (NIS) introductions and the threat they pose to marine biodiversity (Molnar et al., 2008; Galil, 2006, 2012). In terms of threats to native biodiversity, NIS are ranked second only to habitat loss (USGS, 2008).

The transmission of biofouling communities has been documented on several occasions in the oil and gas industry. Offshore platforms provide extensive structures extending down in the water column offer large amounts of surface area exposed to water circulation, thus creating excellent habitat for epibenthic community development. Since platforms are often located in areas that lack hard-bottom habitat, they provide novel substrate for colonization where none previously existed. The oil drilling platform ‘Southern Cross’ originating in Australia was brought to Haifa Bay, Israel, in 2003 for maintenance work including in-water scraping of its extensive fouling. The local divers employed described unfamiliar fish and crustaceans among the dense fauna, and from the shells that had been collected by the divers twelve species of molluscs were identified as new records for the Mediterranean (Mienis 2004).

In the oil and gas industry many vessels are involved throughout operational activities, such as tankers, supply ships, drill-ships, underwater vessels, floating cranes, survey vessels and supply vessels. Untreated hulls will rapidly develop complex fouling communities. The long term presence of hard structures into the sea also results in the creation of hard substratum, which is available for easy colonization by species that may not otherwise have settled in the local habitat. This process can encourage local development (and thence introduction) of NIS, and also offer a stepping-stone for longer-distance relocation of NIS, this latter is especially of concern in the Levantine basin because of the Erythrean invasion (Galil, 2009). Offshore rigs develop fouling communities that could not otherwise survive owing to the depth of water at which the equivalent natural habitat is found.

Upstream and midstream oil & gas activities can create direct and indirect pathways for NIS (IPIECA, 2010). Offshore platforms may facilitate NIS introductions by transferring attached fouling communities, providing new habitat (suitable conditions). Where numerous or in reasonable proximity, as is increasingly common in the Levant, they can also function as corridors for further range expansion (Bulleri and Airoldi, 2005). The network of platforms in the Levant creates “islands” of vertical relief and hard substrate across a mostly soft seafloor environment. As propagules may be transported elsewhere with water mass movements, an NIS introduced on a single platform may become a source for further transfer.

Materials and Methods

The jack-up rig 'Atwood Beacon' was constructed in 2001 and has never been defouled. It was last stationed off Guiana and Suriname (2.5 yrs). The legs were exposed to air for 70 days prior to the survey date (David Sampson, Beacon Operations Superintendent, pers. com.). On October 25, 2012 an examination of the fouling crust on the moveable legs of the rig took place in the port of Limassol, Cyprus, in order to verify the desiccation of the fouling biota so as no NIS is introduced into the Levantine Basin.

Photographic surveying has been a major component of platform biofouling studies. It provides a means of rapidly recording images of multiple surface areas on a platform from which presence and percent cover data can be obtained. Paired with sampling of the biofouling crust to establish species identifications, photo survey greatly increases the area over which distribution patterns can be determined.

Scraping of biota from platform legs has been an integral part of surveys as a primary method and as a ground truth for image-based surveys. Unlike image sampling, it provides specimens for identification and has the potential to sample the entire fouling crust rather than just the visible surface. Scraping biota from a platform is a simple process, but one that is very difficult to quantify and to assure consistency. This study employed heavy metal scraper to chip and pry the dry biofouling mat from platform legs. All freed material was bagged and labeled. This study did not attempt to assure consistent quantitative sampling.

The crust was examined, photographed and samples collected from the legs from the lowest level accessible and up to 40 m above the main deck. The lower part of the legs, which design, contact with the seafloor and potentially uninterrupted immersion during tows make them potentially important biofouling niche, were inaccessible.

Experts, Dr. F. Kerckhof and H. Mienis, carried out the identification of the material. Identified exemplars are archived in the National Collections of Natural History, Tel Aviv University. Exemplar photos by O. Rittner, NCNH, TAU, rig photos by BSG.

Results

The epifaunal crust on all three jack-up legs of 'Atwood Beacon' consisted of a near-identical mix of balanoid barnacles and cementing bivalves. The over-riding characteristic of the fouling communities is that they are a vertical benthos deriving their primary small-scale habitat structure from biogenic carbonate crusts deposited by balanoid barnacles, cementing bivalves (*Chama*, *Ostrea*, *Spondylus*), and byssate bivalves (*Pinna*). All of these foundation species are suspension feeders depending on the passing ocean water for nutrition. The extent of habitat development is limited by a balance between loss of shells and tests and new settlement and growth.

The taxa are listed below.

Cirripedia; Balanomorpha; Balanidae

Balanus trigonus (Darwin, 1854)

(Figure 1)

Balanus trigonus, a very distinctive and easily recognized species, was collected no later than 1864 in southern Brazil (Müller 1867). The species was detected between the 1860s and 1890s across much of the North and South Atlantic Oceans, suggestive of an introduction no later than the 1850s followed by fairly rapid acquisition and entrainment in Atlantic ship fouling communities (Carlton et al, 2011).

Werner (1967) and Zullo (1992) reviewed the history of this Pacific species in the Atlantic basin, where it occurs from North Carolina (Zullo 1992) to Argentina (Spivak et al. 1975, Young 1994) and abundantly throughout the Gulf of Mexico (Gittings 1985); Farrapeira (2010) reviewed its distribution in northeast Brazil. *Balanus trigonus* is common in the open ocean off the southeast coast (Werner 1967, Zullo 1992). Williams et al. (1984) found it to be the only barnacle settling on experimental panels in 27–30 m depth off North Carolina.

Cirripedia; Balanomorpha; Archaeobalanidae
Chirona (Striatobalanus) amaryllis (Darwin, 1854)
(Figure 2a-c)

Chirona amaryllis is native to the Indo-West Pacific, from East Africa to the Philippines and North-East Australia (Newman and Ross 1976). It is a well-known hull-fouling barnacle, introduced to the South-West Atlantic, where it was first recorded in Brazilian waters in 1982 (Young 1989). Specimens were also found on an oil platform docked in Rio de Janeiro state (Carlton et al, 2011). Its presence on platforms sheds light on mechanisms of dispersal and introduction. Specimens were recently identified from the hull of a vessel functioning as a guard ship for the oil and gas industry which operated in tropical West African waters (Kerckhof et al 2010). During the past decades offshore operations for the extraction of oil, gas and minerals increased. The ships used for these activities are deployed worldwide, and contrary to merchant vessels, often stay immobile. The finding of live *C. amaryllis* on a ship's hull in the temperate waters of the port of Oostende (North Sea) indicates its temperature tolerance. In view of the recent spread of *C. amaryllis* outside its native range, its introduction into other warm-water regions, such as the Mediterranean Sea might be expected (Kerckhof et al 2010).

Mollusca: Pectinoida: Spondylidae
Spondylus americanus Hermann, 1781
(Figure 3)

Spondylus americanus, the Atlantic thorny oyster, occurs in the western Atlantic Ocean, its range extends from North Carolina and Texas southwards to Venezuela and Brazil, where it is found at depths between 9 and 45 m. It is a member of the fouling community, found on sea walls, man made structures and vessels. It commonly occurs on offshore oil/gas production structures in the Gulf of Mexico (Dokken et al 2000, Rouse 2009).

Mollusca: Veneroida: Chamidae
Chama macerophylla (Gmelin, 1791)
(Figure 4)

Chama macerophylla, the leafy jewel box clam, occurs along the Atlantic coast of North America, from North Carolina to the West Indies, common as fouler on platforms in the

Gulf of Mexico (Gallaway and Lewbel 1982). The species has been introduced to Hawaii, found to be abundant on the hull of a floating dry-dock in Pearl Harbor (Coles et al 1999).

Mollusca: Osteroida: Osteridae
Ostrea equestris Say, 1834
(Figure 5)

Ostrea equestris occurs along the Atlantic coast of the Americas, from Carolina to the Carribean and Brazil, one of the most abundant species on the nearshore platforms in the Gulf of Mexico (Gallaway and Lewbel 1982).

Mollusca: Pteroida: Pinnidae
Pinna rudis Linnaeus, 1758
(Figure 6)

Pinna rudis is present throughout the Atlantic in warm and temperate waters.

Discussion

The epifaunal crust on the jack-up legs of ‘Atwood Beacon’ consisted of a near-identical mix of balanoid barnacles, cementing and byssate bivalves, serpulid polychaetes and corals. **The two balanids and one of the bivalve species (*Chama macerophylla*) are known invasive species**.

Since offshore energy development is likely to increase in the southern Levantine Basin, a broader integrated evaluation of NIS issues is needed given the potential adverse ecological and economic impacts. Invasive species can alter community structure and function; changes that can adversely effect biodiversity, fisheries, aquaculture, and the built infrastructure (Sheehy and Vik, 2010).

A considerable amount of data related to NIS introductions is available, however, significant data gaps and uncertainty exist. Risk analysis methods can assist in examination of the chances that offshore energy production may result in NIS introductions and the consequences should this occur.

Until comprehensive modeling and analysis tools along with required baseline data are available, a case-by-case evaluation approach is recommended for mobile and towed rigs in the Levantine Basin. Initial application may rely on subjective expert opinion and involve uncertainty, but can aid in reducing potential NIS impacts. Towing rigs aboard a barge deck may reduce survival of propagules depending on surface transit times. In contrast, towing mobile platforms may increase the probability for NIS species surviving transit and serving as a source of propagules for future inoculations. For vessels, dry-dock defouling prior to transit may be more effective than in-water removal methods. Long-distance transfers are problematic if any fouling organisms or ballast water remain.

A biosecurity strategy should be incorporated into existing offshore exploration and production regulations. Using anticipatory management methods based on objective risk analyses may help reduce potential NIS impacts.

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