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Diel shifts and habitat associations of fish assemblages on a subsea pipeline

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ABSTRACT

Nocturnal studies of fish assemblages are relatively rare, particularly at depths greater than 100 m, despite the relevance of diel shifts in habitat usage to fisheries management. This study assesses fish diversity and abundance from remotely operated vehicle (ROV) video recordings that were collected by industry during the day and at night in the course of a subsea pipeline survey, at 130 m depth. A total of 34,862 fish from 41 species and 25 families were recorded along the 23 km of pipeline. The pipeline was characterised by a high abundance of commercially important snapper (Lutjanidae) and grouper (Epinephelidae) species. The fish assemblage sampled along the pipeline during the day differed markedly to that sampled at night time. Several ubiquitous predatory species, e.g. *Epinephelus areolatus, Lutjanus quinquelineatus, Lutjanus russellii,* where present during the day but not at night, likely moving off the pipeline to feed in nearby habitats. Structurally complex mesophotic epibenthic habitat forming invertebrates were observed on the pipeline including; mesophotic corals, crinoids (feather-stars), gorgonocephalids (basket stars), hydroids, true anemones and sponges, but elsewhere in the region, historical trawling effort is thought to have removed such organisms and extensively modified the original habitat. These complex epibenthic habitats were considered to be important to commercial target species and the modification or loss of these habitats is thought to have negatively impacted the valuable commercial fisheries in the region. This study suggests pipelines can offer a significant epibenthic habitat and refuge for fish, potentially comparable to the historical habitats lost to trawling. Fish diversity and abundance was observed to be consistently greater where a gap/crevice existed beneath the pipeline and many species were frequently observed in conjunction with the complex invertebrate matrix above the pipeline, under spanning sections beneath the pipeline and at the pipeline-sediment interface, regardless of time of day. Further dietary analysis, spatially explicit fisheries modelling and off-pipeline surveys on the natural seafloor are required to further investigate the ecological value of pipelines and its influence in fish behaviour. The study builds knowledge of mesophotic coastal fish ecology and will help to inform discussions regarding the ecological and fisheries implications of decommissioning and the removal of subsea infrastructure.

1. Introduction

The diel cycle is known to be a fundamental driver of behaviours in the marine environment (Lowry and Suthers, 1998; Nagelkerken et al. 2000; Ley and Halliday, 2007). Some fish exhibit circadian movements between habitats driven by feeding or reproductive behaviour (Baggerman, 1980, Lowry and Suthers, 1998; Nagelkerken et al. 2000; Ley and Halliday, 2007). Foraging movements can be horizontal along the seabed (Harvey et al. 2012) and/or vertical into the water column to access prey (Beamish, 1966; Neilson and Perry 1990; Gauthier and Rose 2002). Patterns in the diel use of artificial habitats (e.g. pipelines) by fish has received little attention (see Koeck et al., 2013), despite the proliferation of such habitats around the globe.

There can be logistical challenges of studying fish at night. For example, capture techniques such as seine nets may be biased by varying susceptibilities of fish to capture (Lubbers et al. 1990) and visual techniques that utilise lights (e.g. video) are likely to influence fish behaviour (Ryer et al. 2009; Fitzpatrick et al. 2013). Despite the issues associated with using lighting, visual monitoring techniques are non-destructive and provide in-situ observations of fish. A potential resource for surveys of fish is that presented by remotely operated vehicles (ROVs) that are used by the offshore oil and gas industry to perform routine monitoring of subsea infrastructure, often for 24 hours a day over several days. Around the globe, Industry ROV operations collect terabytes of data and at depths usually unobtainable by scientists for ecological research. These data are currently underutilised and

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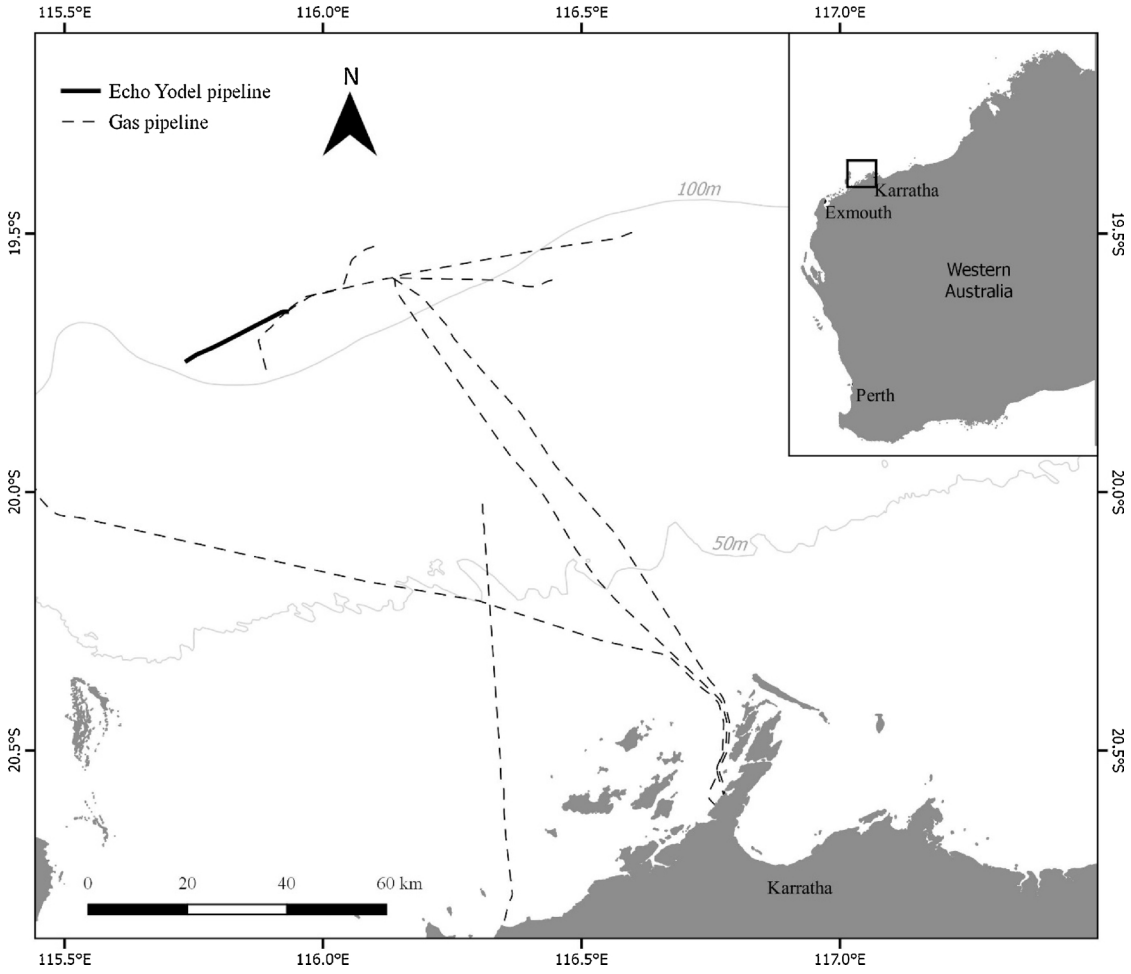

Fig. 1. Location of the Echo Yodel pipeline on the north-west shelf of Western Australia (in bold).

potentially valuable, but have already been shown to unravel mysteries of our ocean (see Gates et al., 2017). In depth investigation of the ecological insights that this footage library can provide is required to better understand the ecology of fish and the ecological value of subsea infrastructure.

Underwater structures, despite being unnatural and having potentially significant negative ecological impacts (Bulleri and Airoldi 2005, Glasby et al. 2007, Sheehy and Vik 2010), have also been shown to provide a suite of benefits to marine organisms (Love and York 2005; Macreadie et al., 2011; Macreadie et al., 2012; McLean et al. 2017). The main impact of these structures, following installation, is the provision of relatively complex three-dimensional hard surfaces that increase habitat diversity for sclerobiont (*sensu* Taylor and Wilson, 2003) organisms, including those generally epibenthic in distribution. The enhancement of fisheries through habitat provision is another potential benefit of retaining sub-sea infrastructure following decommissioning. These ecological benefits, coupled with cost savings due to reduced disposal, has led to the creation of 'rigs to reefs' programs in the United States where decommissioned platforms are retained in-situ (Macreadie et al., 2011; Macreadie et al., 2012). Fish communities can be positively (e.g. Mcdonald et al. 2008) or negatively (e.g. Glasby et al. 2007, Sheehy and Vik 2010) impacted by artificial marine structures and, predicting the responses of fish communities to artificial structures *a priori* with certainty is not possible. In particular, geographic variability in environmental factors such as temperature, currents, tides, and waves, in combination with local organismal diversity, make transferal of knowledge from one marine locale to another difficult. This makes it necessary to conduct local observations and measurements in order to provide evidence to inform best practice in any one geographic area.

There is growing evidence that fish communities can benefit from artificial marine structures specifically associated with the oil and gas industry (e.g. Macreadie et al., 2011; Claisse et al. 2014; Pradella et al. 2014; Fowler et al. 2015), but few observations have been made in the area of interest of this study, the north west shelf (NWS) of Western Australia. One study in this region describes a diverse range of taxa found to be living in association with oil and gas structures in water 85–175 m deep (Pradella et al. 2014). Artificial structures in the region also support populations of the resident serranid, *Pseudanthias rubrizonatus* (Fowler and Booth, 2012). More recently, a comprehensive study of the value of subsea pipelines for fish communities on the NWS was conducted using industry ROV video records (McLean et al. 2017). This research provided further evidence that pipelines in the region offer significant habitat by providing hard substrate for an epibenthic sclerobiont faunal community that supports a diversity and abundance of commercially targeted fish species. Conversely, using artificial structures as a means only to increase fish abundance and diversity is short-sighted, and a multidisciplinary approach to the impacts of installation or in this case, alternatives to removal, should be considered which include social and economic consequences (Sutton and Bushnell 2007).

Determining circadian interactions of fish with subsea infrastructure will provide a better understanding of how fish are utilising such infrastructure and further our knowledge on the importance and value of this infrastructure to fish. Having ROV pipeline inspections occur over a 24 hour period and over many days provides the unique opportunity to investigate this question. The present study aims to utilise industry ROV