Key Threatening Process Nomination Form

for amending the list of key threatening processes under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

2012 Assessment Period

This nomination form is designed to assist in the preparation of nominations of threatening processes consistent with the Regulations and EPBC Act. The listing of a key threatening process under the EPBC Act is designed to prevent native species or ecological communities from becoming threatened or prevent threatened species and ecological communities from becoming more threatened.

Many processes that occur in the landscape are, or could be, threatening processes, however priority for listing will be directed to *key* threatening processes, those factors that most threaten biodiversity at national scale.

For a key threatening process to be eligible for listing it must meet at least one of the three listing criteria. If there is insufficient data and information available to allow completion of the questions for each of the listing criteria, state this in your nomination under the relevant question.

Note – Further detail to help you complete this form is provided at Attachment A.
If using this form in Microsoft Word, you can jump to this information by Ctrl+clicking the hyperlinks (in blue text).

Nominated key threatening process

1. MARINE SEISMIC ACTIVITIES

2. CRITERIA UNDER WHICH THE KEY THREATENING PROCESS IS ELIGIBLE FOR LISTING

Please mark the boxes that apply by clicking them with your mouse.

☒ Criterion A	Evidence that the threatening process could cause a native species or ecological community to become eligible for listing in any category, other than conservation dependent.
☒ Criterion B	Evidence that the threatening process could cause a listed threatened species or ecological community to become eligible for listing in another category representing a higher degree of endangerment.
☒ Criterion C	Evidence that the threatening process adversely affects two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities.

3. 2012 CONSERVATION THEME: Corridors and connecting habitats (including freshwater habitats)

No

4. THREAT STATUS

The nominated key threatening process is not currently listed under State/Territory legislation.

Description of the key threatening process

5. DESCRIPTION

There is an increasing amount of evidence that underwater sounds generated by human activities affect several types of responses in fish, crustaceans, molluscs, marine mammals and marine reptiles (Popper, 2003; McCauley et al., 2003; Popper et al., 2005; Sarà et al., 2007).

Marine seismic surveys involve the use of high-energy, low-frequency noise sources operated in the water column to probe below the seafloor. Almost all routinely-used seismic sources involve the rapid release of compressed air (from an air gun) to produce a pulse that is directed downward towards the seabed, to be reflected upwards again by the density or velocity discontinuities within the underlying rock strata. Typically, pulses are directed to the seabed every 8 to 15 seconds. The returned signals are received, stored, processed and interpreted to give profiles of the sea floor and geology, commonly to depths of 10 km. The technique is used for oil and gas exploration and development, but is also used to monitor the flow of hydrocarbons, and also for maritime engineering fields. In Australia, the majority of seismic activity occurs in Commonwealth waters. Seismic activities can be 2D or 3D, with most contemporary seismic activities in the marine environment being 3D. Seismic airgun arrays are among the most powerful sound sources used at sea. Seismic surveys are considered a chronic stress markedly greater than other anthropogenic stresses, including trawler-induced stress (when trawled fish are released) (Payne et al., 2008). The potential impacts of seismic activity are also not spatially homogenous: there will appear regions with hot spots where the sound level is significantly higher due to geology and geomorphology, which focus the sound (Hovem et al., 2012).

Marine seismic activities occur over a very large area. The large spatial scale of marine seismic surveys is highlighted in the following proposals, the details of which are provided by the proponent and publicly available in the summary of Environment Plans required to comply with Regulations 11(7) and 11(8) of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* and Referral documents under the *Environment Protection and Biodiversity Conservation Act 1999*:

- Apache Energy Ltd (Apache) proposed to undertake a three-dimensional (3D) marine seismic survey program (MSS) within Commonwealth waters of the offshore Carnarvon Basin, which covers an area of approximately 804 km^2 during a 34-day period (24 hour operation)
- Geosciences Australia marine seismic program which was proposed for the Vlaming Sub-basin approximately 31 km south-west of Fremantle, to cover 300 km^2 in approximately 20 days.
- BP Exploration (Alpha) Limited conducted a seismic survey in the Great Australian Bight, which includes coverage of 12,500 km^2 for data acquisition (approximately 67 km^2 per day). Part of the survey area overlapped with the benthic protection zone of the Great Australian Bight Marine Park (GABMP).

The above examples are not intended to be a detailed compendium of marine seismic activities, but are presented to simply highlight the spatial and temporal scale of the activity.

The pulses initiated by marine seismic are broad band, but most energy is concentrated in the 10 – 200 Hertz (Hz) frequency range, with lower energy levels in the 200 – 1000 Hz range. The air-guns are fired repeatedly as the ship traverses an area of interest. In a typical survey, the sound levels from the air-gun array are in the range of 200 – 250 dBrms re 1uPa at 1m. Typically during marine seismic activities, a survey vessel will traverse a series of pre-determined transect lines within the survey area at a speed of approximately 8-9 km/hour. As the vessel travels along the survey lines, a series of noise pulses (every 7-8 seconds) will be directed down through the water column and seabed.
For the purposes of a key threatening process nomination, marine seismic activities are a distinct, specific and clearly identifiable activity.

Despite correlations between cetacean stranding events and seismic activity being demonstrated, a causal link between cetacean stranding and seismic exploration is disputed due to lack of clear data (Compton et al., 2008). However, marine seismic activities are well acknowledged as potentially significant impacts on marine mammals (whales, seals, sea lions and dolphins) (e.g. Mate et al., 1994; Richardson and Würsig, 1997; Gordon et al., 2003). Potential biological effects of air gun noise on marine mammals include physical/physiological effects, behavioral disruption, and indirect effects associated with altered prey availability. Physical/physiological effects could include hearing threshold shifts and auditory damage as well as non-auditory disruption, and can be directly caused by sound exposure or the result of behavioral changes in response to sounds, e.g. recent observations suggesting that exposure to loud noise may result in decompression sickness. Direct information on the extent to which seismic pulses could damage hearing are difficult to obtain and as a consequence, the impacts on hearing remain poorly known. Behavioral data have been collected for a few species in a limited range of conditions. Responses, including startle and fright, avoidance, and changes in behavior and vocalization patterns, have been observed in whales, dolphins and pinnipeds and in some case these have occurred at ranges of tens or hundreds of kilometres.

The Commonwealth has a policy statement for the management of marine seismic activities and whales - *EPBC Act Policy Statement 2.1 – Interaction Between Offshore Seismic Exploration and Whales*. While marine mammals have been the focus of much of the research on putative impacts of marine seismic activities, a similar suite of impacts is occurring across a much wider range of marine taxa, including marine reptiles, demersal and pelagic fish, and macro-invertebrate species. It is examples from these taxa that are the focus of this nomination. The nominated key threatening process can have a number of different impacts on fauna, which cover behavioural, physiological and pathological responses. Animals can be exposed to multiple blasts from seismic activities and as such, the impacts are potentially cumulative. The potential impact depends on: the fauna and its life history stage; the intensity of the air gun discharge and the distance between the seismic source and the animals; the number of seismic shots deployed in a region over a relatively short time period; depth; and features of the seabed itself. It is important to recognise that the same high level of environmental assessment that is applied to the consideration of whales and other listed species is not extended to other components of the marine ecosystem – including (but not limited to) those that contribute directly to food security. The various potential impacts are described and elaborated upon in the remainder of this section.

- *Direct and instantaneous mortality*

While direct and instantaneous mortality (acute impacts) of adult marine fauna are plausible, there is no available information which demonstrates that it occurs in field conditions to the extent that, by itself, such direct and instantaneous mortality could lead to marine seismic activities being a key threatening process. That said, there is correlative information linking the stranding of cetaceans and giant squid with seismic activities (e.g. Engel et al., 2004; Guera et al., 2004), and experimental evidence demonstrating the morphological and ultrastructure mechanism whereby mortality of cephalopods can occur when exposed to acute noise (Andrè et al., 2011). However, given the sensitivities of larvae to anthropogenic environmental perturbations in general, it is plausible, but untested that direct and instantaneous mortality of larvae occurs, although the likely scale of such an impact is unknown. The focus of this key threatening process nomination is on the potential for chronic and cumulative impacts rather than direct mortality.

- *Delayed mortality or significant deleterious impacts as a response of injury or startle responses that affect the overall physiology of the animals.*

There is clear evidence that seismic activity can potentially damage the hearing system of fish and this is documented for captive snapper (*Pagrus auratus*) (McCauley et al., 2000). McCauley et al. (2003) recorded severe damage to fish ears, most likely permanently, at distances of 500 m to several kilometres from seismic surveys.

McCauley et al. (2003) demonstrated that the ears of fish exposed to an operating airgun sustained substantial damage to their sensory epithelia characterized by ablation of hair cells. Peak-to-peak SPLs of 212 dB re 1µPa were recorded but the exact levels/distance at which such damage may have occurred is unknown since the airgun was towed repeatedly from a maximum distance of 800m to a minimum of 5 m. Damage may have occurred at any period during their exposure, or as a result of cumulative exposure. While caution is clearly required in terms of extrapolating the results of captive held fish to field conditions, the results clearly demonstrate damage to fish hearing apparatus from seismic operations can occur. However, relatively short term studies of captive individuals may miss longer term increases in mortality rates (Hirst and Rodhouse, 2000). It is not only finfish that show a response. McCauley et al. (2000) identifies that captive squid showed a strong startle response to nearby air gun start up and evidence that they would significantly alter their behaviour at an estimated 2 to 5 km from an approaching large seismic source.

Christian et al. (2003) exposed adult male snow crabs (*Chionoecetes opilio*), egg-carrying female snow crabs, and fertilised snow crab eggs to energy from seismic airguns. Neither acute nor chronic (12 weeks after exposure) mortality was observed for the adult male and female crabs. There was a significant difference in development rate noted between the exposed and unexposed fertilized eggs. The egg mass exposed to seismic energy had a higher proportion of less-developed eggs than the unexposed mass. It should be noted that both egg masses came from a single female and that any measure of natural variability was unattainable. However, a result such as this does point to the need for further study, and the demonstration that impacts from seismic activities may go unnoticed with cursory assessment, but nonetheless exist and may be potentially significant at the population scale.

Other physiological responses to airgun sound or sound of a frequency consistent with airgun exposure may occur, but the ecological importance of these responses is uncertain and as such a high level of precaution is required until uncertainties are clarified. As an example of a physiological response. Simpson et al. (2005) measured the heart rates of embryonic clownfish exposed on each day of incubation to sounds in the range of 100 to 1200 Hz with source SPLs of 80 to 150 dB re 1 µPa at 1 m. Three days after fertilisation, the heart rates of the embryos significantly increased when exposed to sound. As the embryos developed, a response in heart rate was found over a broader spectrum of sound (from 400 to 700 Hz at 3 days post fertilisation to a maximum of 100 to 1200 kHz at 9 d post fertilisation).

- *Displacement from key habitat*

Overall, the spatial scale of displacement can be ecologically relevant. The displacement of marine fauna as a result of seismic activities is relatively well documented for a number of different species. For example, cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) moved away from a 5.6 x 18 km area in which seismic operations were carried out over a five-day period, and it was documented that there was a reduction in stocks out to the 33 km limit of the sampling undertaken (Engås *et al*., 1996). This example documents the large scale displacement of fish species that can occur. Slotte et al. (2004) carried out a study on the influence of seismic activities on the behaviour of pelagic fish in the northern hemisphere (herring, *Clupea harengus*; blue whiting, *Micromesistius poutassou*; and various mesopelagic species). Their survey work found short-term effects from seismic activities, for both blue whiting and mesopelagic species which were found in deeper waters in periods with shooting compared to periods without shooting, indicating that vertical movement rather than horizontal movement could be a short-term reaction to this noise. Additionally, the abundance of pelagic fish was higher outside than inside the seismic shooting area, indicating a long-term effect of the seismic activity. There were observed anomalies in the Southern Bluefin Tuna fishing area and CSIRO SBT stock assessment throughout the 2012 season, whilst marine seismic surveys were in place.

In cage trials, squid are recorded as being displaced in the water column by seismic activities – specifically moving closer to the surface (McCauley et al., 2000). A number of whale species are also considered to change their behaviour and move to the surface in response to marine seismic activities (McCauley, et al. 2000). When basking at the surface, the loggerhead turtle (*Caretta caretta*) reacts to seismic activity by diving. This is interpreted as an avoidance response by the animal (DeRuiter and Doukara, 2012). Squid are known to be displaced by marine seismic activities, moving towards the surface and also moving away from the sound source (McCauley et al., 2000).

Larval settlement may also be potentially impacted in fish species that utilise ambient noise to identify critical habitat for settlement (Simpson et al., 2004)

Overall, the population implications for any habitat displacements are unknown

- *Disruption of social structures including schooling and spawning aggregations, and disruption to breeding activities in general*

Responses to marine seismic activities from marine fauna are well documented. Fish have been observed to respond by making a startle response with every air gun discharge (Wardle et al., 2001); and in experiments, persistently increased their swimming speed and then schooled more closely (Pearson et al., 1992; McCauley et al., 2000). In field circumstances, fish exposed to marine seismic activities often respond to the disturbance by moving closer to the seabed. Feeding behaviours can also be altered.

Although studies have concluded that the impacts from marine seismic activities are not significant, a number of these studies have only looked at one type of deleterious impact (e.g. instantaneous mortality) and/or suffered from a lack of statistical power such that the chances of detecting a statistically significant impact are remote even if it is occurring, or have not provided the information upon which statistical power can be calculated (Andriguetto-Filho et al., 2005). It is relevant to point out that when statistical power is low, additional precaution is recommended in the management of a disturbance (Underwood and Chapman, 2003).

Although not the focus of this nomination, negative impacts on fisheries are documented from the application of marine seismic activity (Engås *et al*., 1996).

- *Food Web Alteration*

Alteration of the behaviour of animals or indeed direct mortality may alter food webs as a result of a shift in the behaviour. Both predator and prey populations may be impacted. For example, the inferred changed distribution of arrow squid as a result of seismic disturbance may have impacts for species that feed on these animals. Startle responses from finfish exposed to marine seismic disturbance may interrupt feeding activities.

Criterion A: non-EPBC act listed species/ecological communities

6. SPECIES THAT COULD BECOME ELIGIBLE FOR LISTING AND JUSTIFICATION

The following species could become eligible for listing as "vulnerable" under the EPBC Act as a result of the key threatening process:

- black jewfish (*Protonibea diacanthus*);
- Bass Strait scallop (*Pecten fumatus*);
- arrow squid (*Nototodarus gouldi*);
- scampi (*Metanephrops australiensis*);
- blue warehou (*Seriolella brama*);

Black jewfish (*Protonibea diacanthus*)

The black jewfish is a member of the Family Sciaenidae which is well known for the importance that sound generation and reception plays in its life history and habitat use (e.g. Parsons, et al., 2009; Picciulin et al., 2012), in particular in the establishment and coordination of spawning aggregations (Parsons, et al., 2009). The black jewfish is known to form spawning aggregations in northern Australia (Phelan, 2008; Phelan et al., 2008); and in the Northern Territory, known aggregations occur in the vicinity of Darwin, Caution Point, Chambers Bay and Channel Point (Phelan, 2008). Aggregations are likely to occur in other areas of NT and also Western Australia. Black jewfish are found in estuarine and coastal waters over muddy bottoms and offshore to depths of 100 metres.

The species is reported to be in decline, and although fishing mortality has contributed to the decline (Phelan, 2008; Phelan et al., 2008), management measures have been put in place to reduce the level of fishing mortality. Marine seismic activities have the potential to disrupt the social structures including schooling and spawning aggregations, and disrupt breeding activities in general if marine seismic activities overlap temporally and spatially with aggregations of black jewfish.

Bass Strait scallop (*Pecten fumatus*)

The Bass Strait scallop is a bivalve mollusc of the Family Pectinidae. In Australia it occurs in coastal waters from the south eastern Queensland coast (Hervey Bay), around Tasmania in the south, and westward beyond the border between South Australia and Western Australia (Young and Martin, 1989). It is most abundant in the Bass Strait region. The species can occur within sheltered inshore areas (e.g. Port Phillip Bay, D'Entrecasteaux Channel) and exposed, offshore regions (e.g. Banks Strait). The species can be found in depths ranging from 5 to 90 metres, on substrates ranging from mud to coarse sand.

The Bass Strait scallop can usually be found at least partially buried within the sediment, with only the flat, right valve visible. Individual scallops can also be found to occupy small depressions in the substrate, and may be totally covered with sediment. They frequently aggregate into beds, the orientation of which is influenced by the strength and direction of tidal current flows. The species is capable of swimming, and individuals have been observed to rise up to 1.7 m off the bottom and cover horizontal distances of up to 4 m (Young *et al*., 1989). *Pecten fumatus* is a functional hermaphrodite, with individuals generally becoming mature in their second year of life (Young and Martin 1989). Spawning activity has been shown to vary between locations; however, peak spawning activity generally occurs from August to October in southern Tasmania. In general, major settlement periods occur between September and December in southern Tasmania (Fuentes, 1994) and between November and December in eastern Bass Strait (Young *et al*., 1992).

While published work has demonstrated that there is no direct mortality of scallops and no measurable difference in mortalities after seismic survey, anecdotal evidence and currently unpublished survey data demonstrates that high scallop mortality has occurred across several age classes of scallops. This is independent of any direct or indirect fishing mortality and not related to the recruitment dynamics of scallops: previously healthy scallops in no-fishing areas, including an area where commercial scallop fishing has never occurred, have been found to be moribund or recently dead in areas after seismic surveys were undertaken, but not in a similar area of no-scallop fishing where seismic surveys did not occur. A disease issue is an alternative hypothesis for the observations, however, animals were tested by the CSIRO Aquatic Animal Health laboratories, and no infections were found that could be considered responsible for the observed mortailities.

Scallops have sensory systems (statoreceptors) capable of detecting sound and vibration including high amplitude sound in the water column and/or sound energy travelling through the seabed.

Like Pectinids in general, the Bass Strait scallop has a distinct and energetically costly swimming movement – a "startle response" when the animal is subjected to a relevant stimulus. The scallop is exhausted after only a few minutes of active swimming. The act of swimming involves aerobic and anaerobic energy use, with the anaerobic pathway, via the synthesis of octopine, providing the largest fraction of energy required (MacDonald et al., 2006). Repeated swimming responses have been shown to exhaust a scallop's energy reserves quickly and result in significant physiological changes within the scallop (MacDonald et al., 2006).

The activities of seismic constitute a disturbance which will cause protracted bouts of the startle response capable of exhausting the animal. Repeated stimulus can result in a circumstance where the animals become exhausted and are unable to recover physiologically – causing delayed mortality. Additionally in scallops, gonadal maturation leads to virtually complete mobilisation of glycogen from muscle. This does not reduce the capacity of the scallops to mount escape responses, but significantly slows their recuperation from exhaustive exercise (Guderley, 2004). Thus repeated disturbance that elicits a startle response may have a greater impact on scallops during the breeding period than the non-breeding period and this is a critical issue for propagule production.

Marine seismic activities are the most parsimonious explanation for the recent mortalities of beds of *P. fumatus*.

Arrow squid (*Nototodarus gouldi*)

There have been a number of recent examples of correlations between the death of cephalopods (in particular the giant squid) and marine seismic surveys (e.g. Guerra et al., 2004; Andrè et al., 2011). Some of the specimens had lesions in various tissues and organs, but all presented pathologies within the statocysts. Because none of these lesions could be linked to previously known causes of death in the species, the presence of geophysical prospecting vessels in the area suggested for the first time that the deaths could be related to excessive sound exposure (Guerra et al., 2004).

Andrè et al. (2011) document morphological and ultra-structural evidence of massive acoustic trauma leading to direct mortality in four cephalopod species subjected to low-frequency controlled-exposure experiments. Exposure resulted in permanent and substantial alterations of the sensory hair cells of the statocysts, the structures responsible for the animals' sense of balance and position.

It has also been clearly demonstrated that squid sense and respond to marine seismic disturbance through a startle response including the release of ink (McCauley, 2000). Cephalopods have statoreceptor organs that detect noise, and behavioral changes are recorded as a result of seismic activity. In cage trials, squid are recorded as being displaced in the water column by seismic activities – specifically moving closer to the surface (McCauley et al., 2000).

While arrow squid are fished in Commonwealth fisheries, available fisheries information does not suggest that fishing mortality is of concern for the species. However, previous information included in this nomination clearly identifies that direct mortality is feasible, as are behavioural changes and changes in habitat use. While there have been no verifiable instances of direct mortality, anecdotal information from commercial fishermen suggest a correlation between the absence of arrow squid and marine seismic activities. The potential impacts of marine seismic activities are unique and have the potential to significantly disrupt reproduction if the time and location of marine seismic activities overlap with spawning aggregations, as well as potentially produce direct mortality.

Scampi (*Metanephrops australiensis*)

Crustaceans detect the particle motion component of sound (e.g. Lovell et al. 2005), and physiological responses to anthropogenic noise are documented (Wale et al., 2013).

The scampi is a deepwater species occurring in north-western Australia with an historic geographic peak in abundance in the Port Hedland region. There is a commercial fishery for the species, however the species is not considered overfished and the fishery is managed through harvest strategies by the Commonwealth. Scampi aggregate along muddy bottoms of continental slopes and build extensive burrows. They are relatively slow growing and long lived, with moderately low fecundity. They occur in depths of between 250 and 500 metres.

A decline in fishing effort for the species is reported and this is not due to economic factors; rather, fishing operators have considered that the species population has abruptly declined and/or changed its habitat. The observations are correlated with marine seismic operations in the north-west region.

Blue warehou (*Seriolella brama*)

Spawning occurs in winter, although there are some differences in timing throughout the species' range (east of Bass Strait: May-August; west of Bass Strait: June-October). Larvae of blue warehou were widely distributed during winter and spring within shelf and slope waters, although two main spawning areas were recognised: one off the coast of western Tasmania; and another near the border of NSW and Victoria (Bruce et al. 2001; 2002), AFMA (2008) cites recent evidence that the two main spawning areas for blue warehou are located off Victoria, inshore from Gabo Island to Lakes Entrance for the eastern stock; and south west of Portland for the western stock. Larval abundance was highest in the upper 50 m in the study by Bruce et al. (2001). Genetic work suggests that blue warhou comprises two populations: one from eastern Tasmania, and the other from the western Victoria zone (Robinson et al. 2008), with restricted gene flow between the two populations.

The inferred population trend for this species is based on both catch history and standardised Catch Per Unit Effort (CPUE). A key assumption in using CPUE is that it is a robust indicator of abundance (Stobutzki et al. 2011); however, Stobutzki et al. (2011) are concerned about the application of CPUE and abundance to blue warehou because of avoidance of this species by fishers (since the introduction of the bycatch limit), and the sporadic availability, short life span and schooling behaviour of this fish. For many schooling species, CPUE is known to remain high while abundance declines. This 'hyperstability' in the relationship between CPUE and abundance could mask declines in abundance.

While fishing mortality has clearly contributed to the decline in blue warehou, significant management changes have been implemented, but the species is not recovering. There is a significant amount of spatial overlap between the spawning locations of blue warehou and seismic operations.

7. ECOLOGICAL COMMUNITIES THAT COULD BECOME ELIGIBLE FOR LISTING AND JUSTIFICATION

No ecological communities were identified that could become eligible for listing as a result of the nominated key threatening process.

Criterion B: Listing in a higher category of endangerment

8. SPECIES THAT COULD BECOME ELIGIBLE FOR LISTING IN A HIGHER CATEGORY OF ENDANGERMENT AND JUSTIFICATION

The following species could become eligible for a higher category of endangerment under the EPBC Act as a result the key threatening process:

- southern bluefin tuna (*Thunnus maccoyii*) currently listed as conservation dependent;
- orange roughy (*Hoplostethus atlanticus*), currently listed as conservation dependent;
- gemfish (*Rexea solandri*) (eastern Australian population), currently listed as conservation dependent;
- loggerhead turtle (*Caretta caretta*), currently listed as endangered;

9. ECOLOGICAL COMMUNITIES THAT COULD BECOME ELIGIBLE FOR LISTING IN A HIGHER CATEGORY OF ENDANGERMENT AND JUSTIFICATION

No ecological communities were identified that could become eligible for listing in a higher category of endangerment as a result of the nominated key threatening process.

Criterion C: Adversely affected listed species or ecological communities

10. SPECIES ADVERSELY IMPACTED AND JUSTIFICATION

Southern bluefin tuna (*Thunnus maccoyii*)

The southern bluefin tuna is currently listed as conservation dependent.

The southern bluefin tuna (SBT) is commercially fished in Australia for the tuna ranching industry based at Port Lincoln. Southern bluefin tuna (*Thunnus maccoyii*) are found in the southern hemisphere, mainly in waters between 30° and 50° S. The only known spawning area is in the Indian Ocean, south-east of Java, Indonesia. Spawning takes place from September to April in warm waters south of Java and juvenile SBT migrate south down the west coast of Australia. During the summer months (December-April), they tend to aggregate near the surface in the coastal waters off the southern coast of Australia and spend their winters in deeper, temperate oceanic waters. Southern bluefin tuna are considered to be a single stock (Grewe et al., 1997).

The 2011 assessment undertaken by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) suggested that the SBT spawning biomass is at a very low fraction of its original biomass (i.e. around 5%). While seismic activities were not principally responsible for the initial decline, ongoing seismic activities potentially compromise the rebuilding of the stock to the extent that a listing of 'vulnerable' under Commonwealth legislation is possible. Further, marine seismic activities may potentially compromise the ability to reliably assess the status of the stock. Areas where seismic activities occur overlap with areas that represent critical migratory and aggregation areas for juvenile SBT (Basson et al., 2012) and these areas are of international significance as the species is managed by CCSBT, which is an intergovernmental organisation with membership including Australia, the Fishing Entity of Taiwan, Indonesia, Japan, Republic of Korea and New Zealand.

CCSBT relies on two data sets to determine the status of the SBT stock. One of these is the annual January to March CSIRO aerial survey in the Great Australian Bight (GAB). This survey flies the same transects every year, with the transects based on the history of the fishery prior to 1993. Any significant change in the behaviour of the SBT would affect the credibility of the survey, leaving only one data set to assess the SBT stock (that remaining data set is the catch per unit of effort by Japan on the High Seas, which has not proved to be a reliable indicator in the past).

Published examples of tuna hearing frequencies include yellowfin tuna *Thunnus albacares* 50-1100Hz with best sensitivity 89dB at 500Hz; and kawakawa *Euthynnus affinus* 100-1100Hz with best sensitivity 107dB at 500Hz (Iversen 1967). The difference between these species is most likely due to presence or absence of a swim bladder. Yellowfin Tuna (that hear lower frequencies) do have a swimbladder and swimbladders act as a mechanical amplifier of sound (Stoskopf 1993). Song *et al.,* (2006) examined the ear structure of large bluefin tuna *Thunnus thynnus* and suggested from this anatomical study that this species is comparable to those studied behaviourally by Iversen (1967).

These sound ranges and the generalist nature of tuna hearing suggest that SBT would detect the sound emitted in marine seismic surveys. Whilst there has been no specific work on the impacts of air gun noise on tunas (or closely related species); there has been some research (Sara *et al.,* 2007) undertaken on the effects of boat noise on caged

Northern Bluefin Tuna (NBT). The weight of NBT used in this study was up to 50kg, and importantly NBT are anatomically and physiologically similar to SBT with a proportionally sized swim bladder. The results (in Sara *et al.,* 2007) showed tuna changed their schooling behaviour, swimming direction and increased their vertical movement towards surface or bottom of the cage in response to passing car ferries emitting noise in the range of 120 to 137dB (in water re:1µPa) at frequencies up to 200Hz (Sara *et al.,* 2007). These results suggest avoidance behaviour and movement away from the noise source, consistent with a stress/flight response. The boat noise studied is within the frequency and pressure range of the noise spectrum emitted by marine seismic surveys.

Being a pelagic fish, SBT are closer to seismic air guns than demersal species and as such experience a greater intensity of disturbance. Northern bluefin tuna are known to react to boat noise in general which demonstrates that they are responsive to acoustic disturbance (Sara et al., 2007). Northern bluefin tuna are anatomically and physiologically comparable to SBT. SBT routinely undertake vast migrations (Basson et al 2012) and have the ability to rapidly exit an area if sound levels are uncomfortable. The lower than expected results for the CSIRO aerial survey for stock assessment (over the same standard area since 1993), conducted whilst a large-scale marine seismic survey was in place in the GAB area, highlights the uncertainty surrounding the wider effects of this activity. The CSIRO survey results were substantially lower than expected based on the previous seasons' very high proportion of one-year old SBT sighted in the GAB (note that these are not included in the stock assessment as one-year olds, but they return to the GAB area in the following year and are included as two-year olds). This coincided with the largest marine seismic survey ever conducted in the GAB – from November 2011 to May 2012.

The relationship between the marine seismic surveys in 2011/12 and the major change in the migratory pattern of the SBT stock is still being analysed ([redacted] pers. com.). This analysis includes the possible contribution by other factors to the change in migratory pattern (eg, another factor may have been the strength of the Leeuwin Current). The essential point is that no one knows at this stage – except that the two unique events in the data history of the SBT Fishery in the GAB and the GAB seismic surveys occurred in the same year.

In addition, the January-March 2013 aerial survey result has returned to normal – with no seismic survey taking place. The formal assessment of these 2013 results will be available in June 2013.

There is no evidence to suggest that marine seismic surveys have resulted in the direct mortality of any SBT, but it appears probable that the large-scale marine seismic surveys caused a major change in the migratory pattern to areas outside the range and history of the CSIRO aerial survey. This makes the SBT stock assessment highly uncertain. In normal circumstances it would result in SBT being listed as vulnerable or endangered under Commonwealth legislation.

<u>Orange roughy (*Hoplostethus atlanticus*)</u>

The orange roughy is currently listed as conservation dependent.

Orange roughy are found in the mid-slope region at depths of between 700–1200 metres (Elliot and Kloser, 1993). The orange roughy is long lived, slow to mature and exhibits a low recruitment rate with very low fecundity, rarely producing more than 90,000 eggs per female (Branch, 2002; Morison et al. 2007). The orange roughy forms dense spawning and feeding aggregations on or near topographic features such as seamounts, canyons and plateaus. Although uncertainties exist, it is hypothesised that there is limited gene flow between aggregations (Carlsson et al., 2011).

The biomass of orange roughy was significantly reduced by targeted fishing pressure in the late 1980s and early 1990s. Fisheries management of the species has reached the point where orange roughy populations are making a recovery. It is estimated that the population was depleted to 20 to 30% of the initial virgin biomass, depending on the stock structure analysis performed (Koslow et al., 1995). Marine seismic activities have the potential to compromise the recovery of the species and further deplete it in the long term. The risk of future listing under a higher category of the *EPBC Act 1999* depends principally on the recovery of orange roughy populations in key areas (AFMA, 1996). These key areas overlap with marine seismic activities and marine seismic activities have the clear potential to disrupt orange roughy spawning aggregations. Specifically, marine seismic activities have the potential to disrupt the social structures including schooling and spawning aggregations at known spawning periods, and disrupt breeding activities in general if marine seismic activities overlap temporally and spatially with aggregations of orange roughy.

<u>Gemfish (*Rexea solandri*) – east Australian population (eastern gemfish)</u>

Gemfish are long, slender, silvery fish from the Family Gempylidae. Gemfish are found throughout southern Australian temperate waters (Pogonoski et al., 2002). Genetic research indicates that the eastern population of the species extends from waters offshore of Cape Moreton in southern Queensland to the western edge of Bass Strait. This population, referred to as Eastern Gemfish, is distinct from the western population that extends across the Great Australian Bight to Geraldton in Western Australia (Morison et al., 2007). Eastern Gemfish undertake a pre-spawning migration up the southern east coast of Australia, commencing in waters off eastern Bass Strait in early June, travelling north parallel to the coast to spawn off central and northern NSW during a short period in early to mid-August (Pogonoski et al., 2002; Morison et al., 2007). Pre-migratory aggregations occur in eastern Bass Strait.

Eastern Gemfish are found in deeper continental shelf and upper slope waters from 100 m to 700 m in depth. Eastern Gemfish are generally caught close to the sea floor, but are likely to move into mid-water at times (Pogonoski et al., 2002). The most recent stock assessment for Eastern Gemfish was undertaken by CSIRO in 2007 (Little et al., 2008). This assessment found that the biomass of the spawning population in 2007/08 was likely to be 14% of the unexploited spawning biomass of Eastern Gemfish.

While the initial decline of the Eastern gemfish stock was due to commercial fishing, fishery restrictions to protect the species have been progressively implemented since 1988 (Morison et al., 2007). The Eastern Gemfish Rebuilding Strategy describes a series of management measures and responses designed to recover Eastern Gemfish to a prescribed target biomass within a biologically reasonable timeframe (AFMA, 2008).

A potential key threat to Eastern Gemfish is ongoing recruitment depression, or breeding failure, and marine seismic activities have the potential to contribute to this as a result of disturbance to the pre-migratory aggregations of the species which overlap spatially with areas of interest for marine seismic operations.

Loggerhead turtle (*Caretta caretta*) (Western Australian stock)

Loggerhead turtles are currently listed by the Commonwealth as endangered, and flatback turtles are currently listed as vulnerable. Although data gaps exist, population declines of loggerhead turtles in Australia are well documented (Heppel et al., 1996; Shigueto et al., 2008). There are multiple causes for the declines, and management interventions have reduced or eliminated the effects of a number of impacting processes. However, marine seismic activity has the potential to act in concert with remaining impacting processes in a cumulative fashion and contribute to nullifying conservation gains made.

In the presence of marine seismic activities, available information demonstrates the enactment of a general alarm response and a subsequent avoidance by marine turtles in response to air-gun shots, and in some cases temporary or permanent hearing loss (McCauley et al. 2000; Moreira de Gurjao et al. 2005). Based on extrapolations from a small sample of caged loggerhead turtles and green turtles (*Chelonia mydas*) exposed to airgun signals, it has been estimated that a seismic vessel operating 3D air-gun arrays in 100– 120m water depth should impact marine turtles by producing behavioural changes at about 2km range and avoidance at around 1km range (McCauley et al., 2000). Marine turtle populations are likely to be more vulnerable if seismic activities overlap with significant aggregations of marine turtles such as interesting, courtship or dense foraging aggregations (Cuevas et al. 2008). The highest risk is represented by disruptive activities that occur during the time-limited reproductive period.

Overall due to the spatial proximity between nesting locations and marine seismic activities in Western Australia, the Western Australian stock is at particular risk.

Separate to the actual noise from seismic activities, observations exist of marine turtles becoming entangled in seismic apparatus (Weir, 2007). Whether this is a widespread phenomenon when marine seismic surveys are undertaken is unknown.

11. ECOLOGICAL COMMUNITIES ADVERSELY IMPACTED AND JUSTIFICATION

No ecological communities were identified that could be adversely impacted by the nominated key threatening process.

Threat Abatement

12. THREAT ABATEMENT

Much of the current threat abatement for marine seismic activities has focussed on cetaceans (whales and dolphins). The Commonwealth has a specific guideline for abating the threat that marine seismic activities potentially poses to cetaceans. Marine seismic activities are assessed on a case-by-case basis by SEWPAC, through referral of proposed activities under the EPBC Act. This process can only assess the potential impact of seismic activities on currently listed Matters of National Environmental Significance (MNES); it cannot assess the potential of the activity to result in additional species being listed.

An Environment Plan is required to comply with Regulations 11(7) and 11(8) of the *Offshore Petroleum and Greenhouse*

Gas Storage (Environment) Regulations 2009. A review of plans prepared under these Regulations identify they are not comprehensive in terms of the species that they consider and do not consider the full range of potential impacts – for example the possibility of sub-lethal impacts that still may be deleterious to the population of a species as a whole. In effect, the stated provisions of the Regulations do not provide an effective approach for holistic assessment and management of marine seismic activities. State-based guidelines are also not comprehensive with respect to the types of fauna that may be disturbed as a result of the activity. For example, the *WA Guidelines on Minimising Acoustic Disturbance to Marine Fauna* focuses almost entirely on whales, despite including the word fauna in its title. New approaches to better understanding and mitigating the effects of seismic activities on other fauna (e.g. fishes) exist (e.g. Novem et al., 2012) and these have clear scope for consideration in a threat abatement plan.

A threat abatement plan is the approach that can comprehensively address the impacts of marine seismic activities on fauna.

13. DEVELOPMENT OF THREAT ABATEMENT PLAN

The development of a threat abatement plan can be a feasible, effective and efficient way to abate the nominated process. Given the large spatial scale of the potential impact and its easily identifiable and discrete nature, a threat abatement plan has a significant long term chance of success. The development of a threat abatement plan should include all stakeholders potentially impacted and technical expertise across an appropriate range of disciplines including the effects of noise on fish, crustaceans and molluscs.

14. ELEMENTS TO BE INCLUDED IN A THREAT ABATEMENT PLAN

Elements of a Threat Abatement Plan can include (but not be limited to):

- Better consideration of the spatial and temporal overlap between marine seismic activities and key life history events of the fauna identified to be at risk.
- A pathway of continual improvement in the application of marine seismic activities.
- Further ecological research into the impacts of marine seismic activities including rigorous Before-After-Control-Impact experiments at appropriate field scales. This should include analysis within areas where other potential disturbances such as fishing are not permitted. It should also include ecological work that has appropriate statistical power for detection of relevant impacts.
- Consideration of cumulative impacts from multiple marine seismic activities, in particular in relation to spawning aggregations.
- Research aimed at determining further species that may be at risk, and a process for incorporating this information into on-going management of the activity.

15. ADDITIONAL THREAT ABATEMENT INFORMATION

It is identified that there are a number of information gaps in holistically determining the impacts of marine seismic activities. However, given the clear potential for marine seismic activities to result in significant and irreversible environmental impacts, the precautionary principle must be adopted in terms of managing marine seismic activities. The need to adopt the precautionary principle is particularly prudent in this instance because marine seismic activities occur at a large spatial scale, and the potential impacts are varied and complex requiring a considered and holistic approach to assessment and management.

Indigenous Values

16. INDIGENOUS CULTURAL SIGNIFICANCE

No discussion with Indigenous groups, or specifically with Indigenous Australians, has been undertaken in the preparation of this response. It is known however that the Indigenous cultural significance of a number of black jewfish is significant and it is also harvested recreationally by Indigenous fishers (Phelan, 2008). The loggerhead turtle is also of cultural significance for Indigenous Australians. Anecdotally, traditional owners in the Northern Territory have raised concerns regarding the general overall impacts of marine seismic activities on coastal resources. While these general concerns do not at this stage translate into information that is of direct relevance to this nomination, it does highlight that future considerations of marine seismic activities and its assessment needs appropriate involvement with traditional owners.

Reviewers and Further Information

17. REVIEWER(S)

Has this nomination been reviewed? Have relevant experts been consulted on this nomination? If so, please include their names and current professional positions.

18. MAJOR STUDIES

Identify major studies that might assist in the assessment of the nominated threatening process.

In the preparation of this key threatening process nomination, significant information gaps were encountered. These gaps are related to the cumulative impact of marine seismic activities and the impacts which relate to delayed mortality, displacement from habitat, and disruption of key aspects of species life cycles.

These gaps should not be used to delay action; the precautionary principle should be applied to management of the activities.

19. FURTHER INFORMATION

20. REFERENCE LIST

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21. APPENDIX

Please place here any figures, tables or maps that you have referred to within your nomination. Alternatively, you can provide them as an attachment.

22. DECLARATION

I declare that, to the best of my knowledge, the information in this nomination and its attachments is true and correct. I understand that any unreferenced material within this nomination will be cited as 'personal communication' (i.e. referenced in my name) and I permit the publication of this information.

Signed: see separate document

Date:

** If submitting by email, please attach an electronic signature*