NSW Department of Primary Industries submission on PEP11 seismic survey proposal 2014/15

30 August 2014

Attention: Toby Foster, Advent Energy Ltd

Background

Advent Energy Ltd holds an exploration permit (PEP11) to undertake gas exploration activities off the coast of New South Wales. As part of these activities, a three-dimensional (3D) seismic survey has been proposed in the offshore Sydney Basin area over a 4–5 week period between November 2014 and April 2015. Advent Energy is currently undertaking public consultation regarding the proposed survey. The NSW Department of Primary Industries (“the Department”) requests that Advent Energy considers the issues raised in this submission in the development of the Environmental Plan and conduct of the survey.

Commercial Fishing

Significant commercial fishing activity occurs in the proposed survey area, including line fishing (rod/handline and setline), trapping (lobster and fish), and trawling (fish and prawn). Commercial fishers work within a limited geographic range, and are reliant on seasonal trends (including due to long and short term environmental variances) which to a large extent dictate the fishing locations and depths.

Each commercial fisher is authorised to use particular methods by virtue of holding shares in a commercial fishing business structure. Business structures are highly variable – each fishing business may have a specialised or diversified structure in the methods that the business authorisations permit. Fishers may operate exclusively in one fishery or in multiple fisheries or share classes. Individual fishers will have varied economic reliance on the proposed survey area (including specific locations within the overall area), which may influence the impact of the survey activity on viability and economic return to the individual business.

The proposed survey activities could impact on the following fisheries and share classes:

- Lobster Fishery (lobster trapping)
- Ocean Trap and Line Fishery
    - Demersal fish trapping
    - Line fishing western zone (<180m depth)
    - Line fishing eastern zone (>180m depth)
- Ocean Trawl Fishery
    - Offshore prawn trawl
    - Deepwater prawn trawl
    - Fish trawl northern zone

Fishing activity can be broadly separated into attended and unattended activities. Attended activities occur where the fisher is present and actively operating the fishing gear (including trawling and rod/handline fishing). Unattended activities occur where the fishing gear is ‘set’ or left at locations, and checked or retrieved periodically (including set lining and trapping for lobsters or fish). The impact of the proposed survey activities will differ markedly between these two general forms of fishing activity.

As previously advised by Advent Energy (Toby Foster, pers. comm.), the survey will comprehensively cover the proposed area (~100m array width and 100m transects) over the proposed period.

Physical Exclusion

The proposed survey is likely to physically exclude fishers from the area primarily according to the two broad categories of attended and unattended fishing activity.

For attended fishing methods, vessels will not be able to work within a reasonable distance of the proposed path of the vessel, including within the exclusion zone. It is recommended that Advent Energy consider the area of the exclusion zone, the expected speed of the survey vessel, and the anticipated notice which will be given to vessels in or near the survey path. Some vessels will be restricted in their ability to manoeuvre, including due to towing trawl nets or retrieving lines, anchors, or other gear, and that retrieval or movement from the area may take a period of time. Trawlers in particular are expected to be working at night. These factors will determine the expected disruption to this component of fishing activity.

Unattended fishing methods are likely to be more problematic in the way that the proposed survey is likely to exclude this component of fishing activity from the survey area. As above, unattended (or ‘set) fishing gears may consist of lobster traps, fish traps, and/or setlines. Set fishing gears are generally marked on the surface with a number of foam floats, with the exception of lobster traps which may (relatively uncommonly) be set so that the floats are below the water and released to return to the surface with a time release mechanism. Both surface and submerged floats may locate below the surface from time to time due to water pressure on the rope and head gear (dependant on the strength of the current). Currents will have more of an effect in deeper waters, and may in any depth prevent fishers being able to retrieve their gear in anticipation of the presence of the survey vessel on their fishing grounds at predetermined times. Periods of adverse weather may also affect the ability to retrieve fishing gear. Interactions between the survey vessel and set fishing gears are of high concern, both due to the potential loss or movement of the fishing gear, and the potential to affect the survey array and/or vessel.

Set fishing gear may be set for varying periods, depending on the method, depth, and target species. Setlines are generally checked on a daily basis, fish traps may be checked daily or after several days, and lobster traps may be checked anywhere from daily to weeks or months from setting. These setting times are often dependant on the target species, longevity of baits, and cost efficiencies in travelling to fishing grounds. Considering this, the survey activities are likely to exclude set fishing gear from the area for significant periods of time if interactions are to be avoided.

It is not recommended that a vessel chartered by Advent Energy should move set fishing gears from the path of the survey vessel. Whilst DPI could facilitate an authorisation for persons on the proposed vessel to move (interfere) with set fishing gear (an offence under the *Fisheries Management Act 1994*), this is not practical because: when gear is retrieved from depth, barotrauma is likely to cause mortality of any fish in traps or on setlines, thus preventing fishers capturing those fish or redeploying the gear; fishing gear is likely to be moved from specific locations where good catches are received (even a small movement can have a large impact on catches); fishing gear may be lost as the owner may not know if or where it has been moved (head gear can be hard to see at sea, and may be submerged by currents after being moved); and setlines cannot be retrieved and redeployed without removing any fish and/or snoods (in the case of clips being used to attach hooks via short lines to mainline), and rebaiting (i.e. completing the fishing activity). It is further recommended that fishing locations should not be disclosed in any way, as specific locations are effectively intellectual property of individual fishers.

Effects of seismic survey sonic discharges

The Department has conducted a review of available information on the effect of seismic surveys on commercial fishing and fish populations (Attachment 1). It is important to note that the proposed three-dimensional (3D) survey involves a greater density of measurements, and likely an increased number of seismic sources than previous two-dimensional (2D) surveys which have been conducted in the area. This makes it difficult to estimate the impact of the survey on commercial fishing, however it is likely to exceed that of previous surveys. In addition, careful comparison must be made with available research conducted in limited controlled circumstances, which may describe effects very different to a sustained detailed real world survey.

The available information suggests that potential disturbance (including impact on commercial fishing) can be highly variable depending on the specific survey method and local conditions including water depth, temperature profile, and bottom type. A range of these conditions are expected to be present throughout the survey area. Further, impacts may vary depending on the characteristics (and susceptibility to disturbance) of individual species and the characteristics of fishing methods. Impacts (including decreased catches) can be significant, can persist for some time after the completion of the survey activity, and may extend outside the specific survey area. It is important to note potential behavioural impacts on Eastern

Rocklobsters which are likely to be traversing the survey area in their northward migration for spawning activity during the proposed survey period.

Reported catches in the survey area

A review of commercial catches in the survey area over a four year period (July 2009 to June 2013) has been completed (Attachment 1). In this time, between 23 and 27 fishing businesses have reported between 73.9 and 121.7 tonnes of product per annum, with a gross value of between $12,821 and $126,407 per month. Whilst significant variability is present, the importance of the survey area to individual fishers may depend on availability of product in the survey area and adjacent areas, and their reliance on the survey area for specific catches or species during different times of the year.

It is particularly important to note the economic importance of catches in the periods leading up to Christmas and Easter each year. Demand for seafood products increases and significant increases in price (and reduction in high product volume price depression) results in increased monetary returns to fishers, secondary receivers, and transport (and other support) industries.

Consultation

The commercial fishing industry is characterised by highly independent individuals with variable official and social relationships. The economic reliance on the survey area and therefore direct interest in the survey will vary according to the fishing operations of individual commercial fishers. Engagement by Advent Energy through an effective consultation program will be critical in assessing and reducing the likely impact of the survey, in providing for any required alteration of routine commercial fishing activities prior to or during the survey and determining the actual impact after the survey.

Both written correspondence and face-to-face meetings are recommended to maximise consultation and determine best pathways to communicate directly with fishers during the survey. Limited response to written material is often experienced from commercial fishers and this should not be taken to be a true representation of the interest in the survey and appropriate design of the Environmental Plan. Consultation programs are likely to be required before, during, and some time after the survey.

Recommendations – Commercial Fishing

1. Advent Energy recognises the significance of commercial fishing activity within the survey area and the potential impacts on the viability of individual fishing businesses and operations before, during, and after the survey activity.
2. Advent Energy specifically addresses the issues in this submission and any subsequent consultation in the preparation of the Environmental Plan and conduct of the survey.
3. Advent Energy provides for effective consultation engagement directly with commercial fishers, Fishermen's Co-operatives, and the NSW Professional Fishermen's Association before, during, and after the survey in order to minimise the impact on commercial fishing, and assess what the impact was during the survey. It is further recommended that sound consultation (including post survey) will be critical in ensuring industry confidence in Advent Energy's operations and commitment to reducing the impact on current and/or future exploration or production programs.
4. Advent Energy minimises impact on economically important periods, including prime fishing periods in the lead-up to Christmas and Easter. It is further recommended that Advent Energy engage Fishermen's Cooperatives and the Sydney Fish Market as significant primary receivers of commercial seafood products.
5. Advent Energy notifies Nicholas Giles, Commercial Fisheries Manager at Nicholas.giles@dpi.nsw.gov.au regarding the proposed dates the survey vessel will be operating, and the proposed routes or area coverage within specified periods.

Recreational and Charter Fishing

Recreational fishing (stationary, drifting, and trolling line fishing) occurs within the proposed survey site, including both private recreational and commercial charter fishing. The most popular time for fishing in the area is from mid-December through to mid-April, peaking over the holiday periods of Christmas and Easter and during the period from early January to mid-March.

The Swansea Fish Attracting Device (FAD) is located at 33 10.005E, 151 48.976S, within the survey boundaries. The FAD is a floating buoy anchored to the sea floor that will be deployed between 1 November 2014 and 30 June 2015. FADs are installed with the primary purpose of aggregating pelagic fish species to improve offshore recreational fishing opportunities and as such are key fishing locations for recreational fishing. If the exploration activities require removal of this installation to complete the necessary works, DPI would appreciate as much notice as possible to enable removal to be programmed into work schedules.

Advent has advised that direct consultation with key recreational fishing groups will be undertaken, and contact details have previously been provided by the Department for that purpose. Appropriate advisory programs to warn fishers of survey activity should be a critical aspect of the program.

The Department can further assist in advising fishers by utilising our existing communication channels such as Newscast (the electronic recreational fishing newsletter circulated to approximately 120 000 recreational fishing licence holders) and Charter Chatter (the electronic charter fishing newsletter). We will however need advanced notice of survey dates and associated information as these publications typically get published every 2 months. Information can also be posted on the NSW DPI Fisheries Facebook page (this can be done on a shorter notice basis).

Recommendations – Recreational Fishing

1. Advent Energy recognises the significance of recreational and charter fishing activity within the survey area, including associated expenditure and benefit to regional economies.
2. Advent Energy minimises impact on popular and peak recreational and charter fishing times to minimise disruption to fishing and fishing competitions during the peak recreational fishing season.
3. Advent Energy provides for effective consultation directly with recreational and charter fishers.
4. Advent Energy liaise directly with Phil Bolton, Fisheries Manager, Recreational Fisheries, regarding arrangements for the Swansea FAD.
5. Advent Energy notifies Phil Bolton, Fisheries Manager, Recreational Fisheries, via email at Phil.bolton@dpi.nsw.gov.au regarding the proposed dates the survey vessel will be operating, and the proposed routes or area coverage within specified periods.

More information

Should you require further information on this submission, please contact Nicholas Giles, Commercial Fisheries Manager at Nicholas.giles@dpi.nsw.gov.au or on (02) 6652 0919 or 0419 185 540, or Phil Bolton, A Fisheries Manager, Recreational Fisheries at Phil.bolton@dpi.nsw.gov.au or on (02) 4424 7411 or 0419 464 798.

Department of Primary Industries

NSW FISHERIES | COMMERCIAL FISHERIES MANAGEMENT

Information paper: potential effects of seismic surveys on fish and fishing activities

Attachment 1 - August 2014

Background

Advent Energy Ltd holds an exploration permit (PEP11) to undertake gas exploration activities off the coast of New South Wales. As part of these activities, a three-dimensional (3D) seismic survey has been proposed in the offshore Sydney Basin area over a 4–5 week period between November 2014 and April 2015.

Concerns have been raised over potential conflicts with commercial, recreational and charter boat fishers and possible immediate and long-term effects to fishing catches and aquatic organisms in the survey area caused by sound pollution from the seismic emissions. This paper provides a brief summary of the main research findings to date regarding the potential effects of seismic surveys on fish and fishing activities and an overview of the commercial fishing species and activities likely to be affected in the proposed survey area of PEP11.

Seismic signals and underwater sound

Offshore seismic surveys use short pulses of high-intensity, low-frequency sound, usually rapid releases of compressed air, to penetrate the seafloor and reflect the geophysical features in the underlying rock strata. The seismic signals are usually produced by an array of air guns towed below the surface (at 5–6 metres depth) that fire at rapid intervals (every 6–20 seconds).

Over a 24 hour period a single surveying vessel travelling at a typical speed of 4 knots may cover 178 kilometres of tracklines and discharge over 14,000 air-gun shots (Hirst and Rodhouse 2000). More intensive 3D surveys typically use two air-gun arrays to examine localised areas for longer periods, and individual tracklines may be separated by as little as 50–100 metres.

While seismic signals are directed down towards the seafloor, considerable sound energy may be propagated horizontally over many kilometres from the survey area (Handegard et al. 2013). Water is an excellent medium for sound transmission because of its high molecular density. Sound travels about five times faster, over greater distances and at higher amplitudes in water than in air (Slabbekoorn et al. 2010). The area of potential disturbance from seismic surveys can be highly site-specific and is dependent on the specific seismic methods used and local conditions, such as water depth, temperature profile and bottom type.

Potential effects of seismic surveys on fish and fishing activities

Many of the studies that have investigated the effects of seismic surveys or other underwater sound pollution on aquatic organisms have focused on marine mammals, and in particular cetaceans (dolphins and whales). These effects have been summarised in several comprehensive reviews (e.g. Gordon et al. 2003; Weilgart 2007) and will not be reiterated here. Many jurisdictions have already introduced policies aimed at mitigating or minimising effects of seismic surveys on marine mammals (e.g. DEWHA 2008).

Far less is known about the effects of seismic surveys or air-gun emissions on fishes and marine invertebrates and fishing catches (Popper and Hastings 2009). The limited studies to date have reported mixed results from no detectable effects to a wide range of effects, including: mortality of early life stages; stress and other physical damage; hearing loss and auditory damage; behavioural changes such as startle responses and avoidance; and altered fishing success due to large-scale shifts in horizontal and vertical distributions of fish.

A brief summary of the main research findings to date are provided below, but readers are referred to the original literature sources and reviews listed at the end of the paper for more detail. It should also be noted that many of the reported effects are highly species-specific and often depend on the particular seismic survey exposure regime tested and/or signal sources being above certain threshold levels or within minimum exposure distances. So, caution must be exercised in extrapolating the results from these studies to different species or seismic survey regimes (Fewtrell and McCauley 2012).

Mortality

No studies to date have demonstrated direct mortality of adult fish in response to air-gun emissions, even when fired at close proximity (within 1–7 metres, Boeger et al. 2006). Although some fish deaths have been reported during caging experiments, these were more likely caused by experimental artefacts of handling or confinement stress (e.g. Hassel et al. 2004). For free-swimming fish that are able to move away from seismic sources as they approach the potential for lethal physical damage from air-gun emissions is even further nullified.

This does not preclude, however, the potential for indirect mortality from human-generated sound pollution (Slabbekoorn et al. 2010). Given the poor attenuation of light in water and often turbid conditions, many aquatic organisms depend on highly sensitive hearing rather than vision for many of their critical life functions, including communication, prey detection, predator avoidance and navigation (Weilgart 2007).

The sound generated by air guns is within the range of frequencies detectable by the hearing of most fishes (Pearson et al. 1992). Interference from these human-generated sounds may impede the fishes ability to hear biologically relevant sounds, which may in turn affect their behaviour and indirectly their fitness or survival (Slabbekoorn et al. 2010). Given the difficulties associated with collecting reliable data on sub-lethal effects, no studies to date have demonstrated indirect mortality of fish caused by air-gun emissions. However, for cetaceans and giant squids there is mounting evidence that some stranding mortalities may be linked to seismic activities (Gordan et al. 2003; Guerra et al. 2011).

Early life stages of most marine fish and invertebrates have limited swimming ability and would be unable to move away from seismic sound sources. Unfortunately, very little is known of the effects of air-gun emissions on these early life stages and studies to date have reported mixed results, with effects usually only occurring at close ranges (within metres rather than kilometres).

Larvae of the New Zealand scallop (*Pecten novaezelandiae*) that were exposed to playbacks of pre-recorded seismic air-gun pulses in captivity showed significant developmental delays and 46% developed growth abnormalities (Aguilar de Soto et al. 2013). In contrast, the survival of larvae of the Dungeness crab (*Cancer magister*) held in containers in Burrows Bay, Washington and exposed to a single discharge of an array of seismic air guns was not significantly affected (Pearson et al. 1994).

Trials of seismic air-gun emissions as a method to reduce the survival of non-native lake trout (*Salvelinus namaycush*) embryos in western USA produced high mortalities (of up to 100%), but only at close range (0.1 meters distance) (Cox et al. 2012). At distances of 2.7 metres mortalities did not differ from those of controls.

Eggs, larvae and fry of Atlantic cod (*Gadus morhua*) held in containers in the open ocean and exposed to air-gun discharges at distances of between 1–10 metres showed no mortality or changes in feeding success (Dalen and Knutsen 1987). Some older fry (aged 110 days old) developed balance problems, but these apparently recovered within a few minutes.

Stress and other physical effects

Other sub-lethal effects from exposure to air-gun emissions include physiological stress responses. A significant increase in stress (as indicated by changes in blood and tissue chemistry) was detected in caged European sea bass (*Dicentrarchus labrax*) exposed to air guns fired in the open ocean at a distance of 180-800 metres (Santulli et al. 1999; La Bella et al. 1996). Recovery to pre-exposure levels was recorded within 72 hours after emissions ceased. No physical damage to their skeletons was observed in x-rays. In contrast, McCauley et al. (2000) detected no significant changes in similar stress response blood metabolites in fish that could be directly attributed to air-gun exposure.

It should be noted that most observations of acoustic stress responses have been described for caged fish and it is unknown whether free-swimming fish that could move away from the seismic sound source would show similar responses. Furthermore, it is possible that the stress responses have arisen because fish try to escape from the sound source and are unable to because of their confinement, rather than from the sound source itself.

Results from unconfined sedentary invertebrates suggest that acoustic stress responses *per se* can occur. For example, golden venus clams (*Polititapes aurea*) dredged up after passage of a seismic array overhead showed increased stress blood metabolites relative to controls (La Bella et al. 1996).

Reports of other physical damage to compressible internal organs (e.g. swim bladders) or tissues vulnerable to embolism from air bubbles or internal bleeding from ruptured capillaries (e.g. brains) have arisen primarily from studies using underwater explosives and other high-pressure sound waves, and not from air-gun emissions that generate a lower maximum pressure and pressure change (Popper and Hastings 2009). Other than physiological stress responses, auditory damage and associated hearing loss (as discussed below) no other physical damage to adult fish or invertebrates have been directly attributed to exposure to air-gun discharges, even at close proximity.

Hearing loss and auditory damage

Fish lack a middle or external ear like most terrestrial vertebrates, but do have paired inner ears within the cranial cavity adjacent to the brain. Sensory hair cells within the inner ears transduce sounds into electrical signals for transport by the nervous system and interpretation by the brain. High intensity sounds can fatigue, damage or ablate sensory hair cells, leading to temporary or permanent hearing loss (McCauley et al. 2003; Popper and Hastings 2009). However, there is evidence that fishes, unlike mammals, continue to produce sensory hair cells for much of their lives and can possibly replace or repair damaged cells and recover hearing function (Smith et al. 2006).

Snapper (*Pagrus auratus*) held in cages and exposed to signals from an air gun towed towards and then away from the cages sustained extensive damage to their sensory hair cells that did not repair up to 58 days after exposure (McCauley et al. 2003). However, the authors were unable to ascertain what part of the seismic signals caused the damage; i.e. whether it was a few intense close range signals or the cumulative effect of elevated noise levels over time. Furthermore, the effects of the impaired hearing on overall fitness and survival was only speculated (rather than measured) to include reduced ability to detect predators and prey and sense their acoustic environment.

Similar effects have been described for four species of cephalopod – common cuttlefish (*Sepia officinalis*), common octopus (*Octopus vulgaris*), European coastal squid (*Loligo vulgaris*) and oceanic squid (*Illex coindetii*) – after exposure to medium-intensity, low-frequency sound pulses in tanks. Effects included missing or damaged hair cells and lesions in the lining of the statocysts (equivalent to fish inner ear) (André et al. 2011; Solé et al. 2013).

Effects to hearing and auditory tissues may be quite species-specific or only occur under some acoustic exposure regimes. Less detrimental effects were noted in three northern hemisphere fish species – northern pike (*Esox lucius*), broad whitefish (*Coregonus nasus*) and lake chub (*Couesius plumbeus*) – exposed to an air-gun array in the McKenzie Delta, Canada. Only temporary hearing loss was noted for two of the species, with full recovery within 24 hours (Popper et al. 2005).

As above, these effects have been described for caged or captive fish that could not move away from the sound source. Behavioural observations of the caged snapper, suggested that the fish would have fled the sound source if possible (McCauley et al. 2003). However, demersal, reef or bottom-dwelling fish (e.g. flatheads and flounders) that show greater site attachment may be less inclined to flee from a seismic sound source and experience greater effects as a consequence.

Behavioural changes

Because of the ability of most species of free-swimming fish to flee the approach of a seismic sound source, air-gun emissions are more likely to result in behavioural effects than physiological or physical damage to fish (Pearson et al. 1992). Close exposure to seismic air-gun emissions have produced alarm and startle responses, similar to those observed in fish schools under attack by predators, in most fish species during captive experiments (Pearson et al. 1992; McCauley et al. 2000). Responses have included flexions of the body followed by rapid swimming or a series of shudders or tremors during each air-gun discharge (Pearson et al. 1992; La Bella et al. 1996; Wardle et al. 2001; Hassel et al. 2004; Boeger et al. 2006)

McCauley et al. (2000) reported greater startle responses in smaller fishes and with increased intensity of received sound. The severity of startle responses also lessened over time suggesting that fish gradually habituated to the increased sound levels (Boeger et al. 2006). Fishes tend to remain lower in the water column and/or swim faster and form tighter schools during periods of close air-gun emissions. A return to normal behavioural patters has been observed within 14-30 minutes after air-gun emissions have ceased (Fewtrell and McCauley 2012).

Other behavioural changes have included shifts in vertical distribution (either up or down), immobility (freezing) near the bottom and changes in schooling behaviour (increased milling, undirectional swimming, increased swimming speeds or flash expansion in random directions) (Pearson et al. 1992; Wardle et al. 2001; Hassel et al. 2004).

Caged squid (*Sepioteuthis australis*) have also displayed startle and alarm responses to air-gun emissions, including ejecting ink and/or jetting away from the air-gun source (McCauley et al. 2000; Fewtrell and McCauley 2012). They also showed increased swimming activity and avoidance behaviour by staying at the water surface and end of the cage furthest from the air-gun source.

Many of the above experiments have assessed behavioural changes to air-gun emissions for fish held in cages and unable to flee or avoid approaching survey vessels. Free-swimming fish have the option to flee or avoid an approaching survey vessel, but the precise reaction is likely to be quite species-specific (Boeger et al. 2006).

Acoustically tagged reef fish and marine invertebrates (crustaceans, echinoderms and molluscs) showed no signs of moving away from an inshore reef near Scotland during air-gun operations, and while they showed startle responses during the shooting, their initial swimming directions were not altered (Wardle et al. 2001). In this experiment, however, the air-gun source was stationary and did not gradually build or fade in intensity as would occur if towed behind a moving vessel. Furthermore, some tagged Pollack did cease their normal diurnal movement patterns for several days after exposure.

In a similar reef habitat exposed to a full commercial 3D seismic survey off Western Australia, no significant changes in the diversity or abundance of the reef fish community were detected via underwater visual transect surveys (Miller and Cripps 2013). There was also no evidence of direct mortality or indirect mortality from sub-lethal effects among site attached species, such as Pomacentrids that tend to hide within coral heads or reef crevices when startled rather than flee.

Fishing success effects

Aside from the possible physical exclusion of vessels from seismic survey areas, changes in the horizontal and vertical distributions of fish or other behavioural changes (e.g. responsiveness to fishing gears or general activity levels) during or after exposure to seismic signals can also significantly influence catches of commercial and recreational fisheries (Hirst and Rodhouse 2000). However, these are likely to show considerable gear- and species-specific variation (Løkkeborg et al. 2012).

Reduced abundances of demersal fish species (by 36%), large pelagics (by 54%) and small pelagics (by 13%) were reported after seismic shooting in Norway, which has a long history of seismic surveys over commercial fishing grounds (Dalen and Knutsen 1987). But subsequent bottom trawl catches increased (by 34-290%). These results combined suggested that demersal fish moved to the bottom where they became more vulnerable to trawl gears, whereas large pelagic species apparently fled the area.

Significant catch rate reductions (by 52%) were also recorded for a hook-and-line fishery for rockfish (*Sebastes* spp.) along the central Californian coast following exposure to a single air gun (Skalski et al. 1992). Changes in the height but not areal size of the fish aggregation were recorded, and the reduced catch rates were attributed to the collapse of fish schools toward the bottom and decreased responsiveness to baited hooks rather than dispersal of the fish from the area. Behavioural changes like these are thought to recover more rapidly than the dispersal of fish away from a fishing area.

During and after seismic surveys in the Barents Sea, Norway, commercial trawl and long-line catch rates of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) also decreased by 50-80% (Løkkeborg and Soldal 1993; Engås et al. 1996). The effects were most pronounced for larger fish, which essentially disappeared from catches of both gears during and after seismic shooting. Acoustic mapping of fish densities and distributions showed that in this case fish were displaced from the area exposed to the air-gun array (Engås et al. 1996). Effects were recorded at distances as great as 33 kilometres from the area and for up to 5 days after shooting was completed (Engås et al. 1996). These were the maximums recorded, but the absolute outer distances of effects and the entire period over which catches were reduced were not assessed.

Not all results to fishing catches have been negative. During a seismic survey on one Norwegian fishing ground, gillnet catches of golden redfish (*Sebastes norvegicus*) and Greenland halibut (*Reinhardtius hippoglossoides*) increased (by 86% and 132%, respectively), while long-line catch rates of the two species decreased (by 16% and 25%, respectively) (Løkkeborg et al. 2012). The increased catches of the bottom-set gillnets were attributed to the greater movement of fishes and their descent towards the bottom during seismic shooting.

La Bella et al. (1996) detected no significant differences in catches taken by trawling, gill-netting or clam dredging before and after experimental seismic shooting in the Adriatic Sea, although the total duration of the shooting was fairly short (6 profiles covering a total of 111.3 km). The catches examined included a wide range of species from pelagic, demersal and benthic fishes, lobsters, mantis shrimp, squid and clams.

Shrimp catches in a Brazilian artisanal trawl fishery showed no immediate effect to exposure with an air-gun array for a single afternoon (Andriguetto-Filho et al. 2005) and feeding Atlantic herring (*Clupea harengus*) schools off northern Norway showed no changes in swimming speed, direction or school size in response to a transmitting seismic vessel as it approached from a distance of 27 to 2 kilometres, over a 6 hour period (Peña et al. 2013).

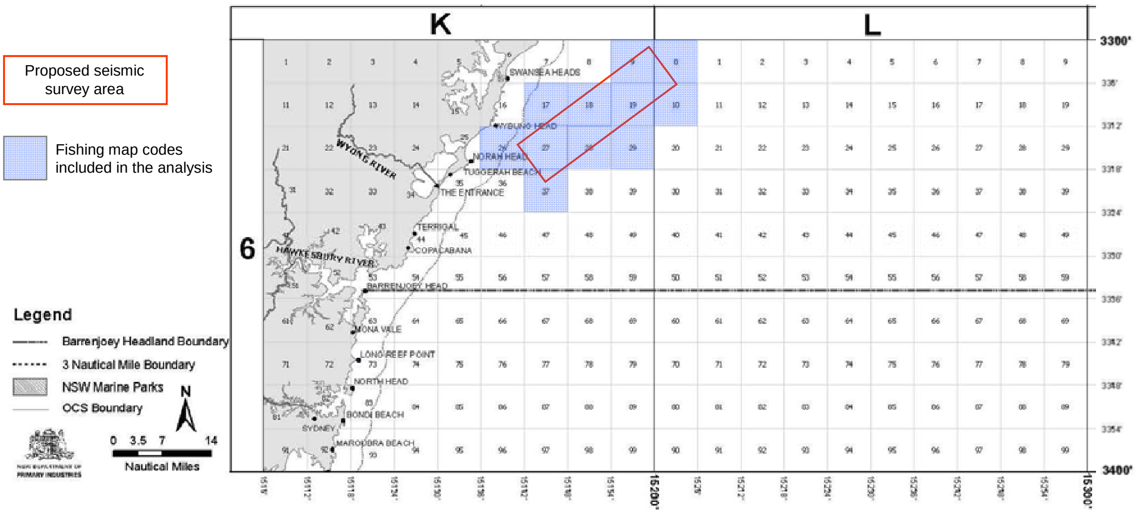
Studies of potential long-term effects of seismic surveys on commercial catches are rare and are usually complicated by other seasonal or effort related variation in fisheries data (Hirst and Rodhouse 2000). Sandeel fleet catches in Norway showed reduced landings for up to 2 weeks following an experimental 3D seismic survey, but other factors (e.g. public holidays and periods of poor weather) may have contributed to these declines (Hassel et al. 2004).

Commercial trawl catches of prawns off Sydney declined over the four months following a seismic survey in 1991, but this was consistent with a seasonal decline in catches over those months during the previous 15 years (Steffe and Murphy 1992). Likewise, there was no evidence of any long-term declines in commercial catch rates of rock lobsters following 33 seismic surveys conducted offshore from western Victoria between 1978 and 2004, and no short-term changes in catch rates were detected in three areas subject to more intensive 3D seismic surveys (Parry and Gason 2006).

Summary of fish and fishing activities in the proposed survey area

Commercial catch and effort data for fishing map codes were compiled for this summary (Figure 1). Because of the grid layout of NSW fishing map codes and the diagonal orientation of the proposed survey area, the map codes assessed cover a slightly larger area than the proposed survey area, but this was necessary to ensure all possibly affected map codes were included in the analysis.

Figure 1. Commercial fishing grid codes included in catch estimates for the proposed survey area over last 4 years (June 2009 to July 2013).



Fish species

A total of 149 marine species have been reported in commercial catch landings taken from the proposed seismic survey area over the last four years (July 2009 to June 2013). Of these, 70 species have accounted for the bulk (99%) of the landings and are listed in Table 1 in order of importance in landings, while the remaining 79 species have been reported only occasionally and in smaller quantities (these comprise only 1% of the landings).

The main species reported in commercial catch landings taken from the proposed seismic survey area encompass a wide range of fish physiologies and ecologies, from demersal and bottom dwelling species (e.g. flatheads) to small schooling species (e.g. eastern school whiting and yellowtail scad) and large pelagic species (e.g. Australian bonito). Demersal or bottom dwelling species are likely to show greater site attachment and reduced inclination to flee the area than pelagic species.

The list also includes a range of valuable invertebrates, including cephalopods (squid, octopus and cuttlefish) and crustaceans (prawns, rock lobsters and bugs), which differ quite markedly from teleosts in their anatomy and auditory systems. Likewise there are various shark and ray species reported in the landings. Particular consideration should also be given to species that may use habitats within the proposed survey area for spawning, migration or larval development or dispersal during the proposed survey period.

Fishing activities and landings

The survey area is regularly fished by commercial fishers endorsed in the Ocean Trawl Fishery, Ocean Trap and Line Fishery and Lobster Fishery. Over the last four years (July 2009 to June 2013), between 23 and 27 fishing businesses have reported commercial catches from the survey area, with combined landings of between 73.9 and 121.7 tonnes per annum. Combined monthly landings have varied considerably across the four year period (Figure 2), from 2.8 to 23.6 tonnes and an average of 8.2 tonnes per month.

The estimated value of the combined landings from the proposed survey area have ranged from $12,821 to $126,407 per month over the last four years (July 2009 to June 2013), with an average of $43,327 per month.

Figure 2. Monthly landings of commercial fisheries catch taken from proposed survey area over last 4 years (June 2009 to July 2013).

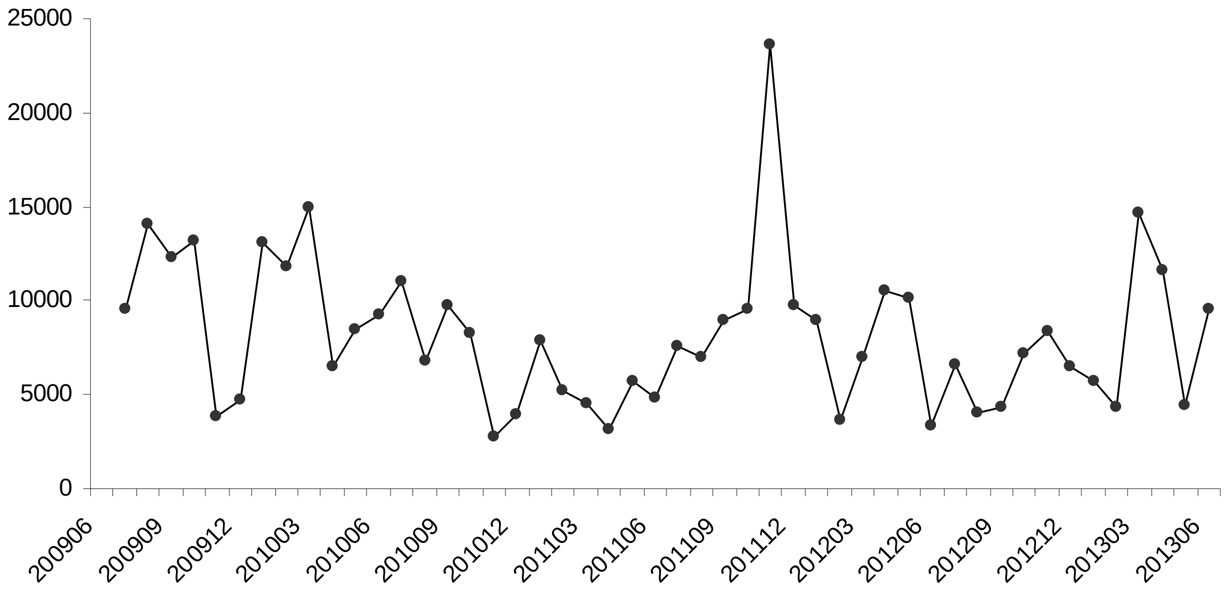


Table 1. Top 70 fish species landed by commercial fishers over last 4 years (June 2009 to July 2013), in descending order of importance in landings. These species comprise 99% of the catch landed in the area.

Common name	Species name
Tiger Flathead	*Neoplatycephalus richardsoni*
Ocean Jacket	*Nelusetta ayaraudi*
Eastern School Whiting	*Sillago flindersi*
Bluespotted Flathead	*Platycephalus caeruleopunctatus*
Australian Bonito	*Sarda australis*
Yellowtail Scad	*Trachurus novaezelandiae*
Snapper	*Pagrus auratus*
Silver Trevally	*Pseudocaranx georgianus*
Australian Angelshark	*Squatina australis*
Leatherjacket (other)	Monacanthidae
Southern Calamari	*Sepioteuthis australis*
Eastern Shovelnose Ray	*Aptychotrema rostrata*
Red Gurnard	*Chelidonichthys kumu*
School Prawn	*Metapenaeus macleayi*
Redfish	*Centroberyx affinis*
Common Sawshark	*Pristiophorus cirratus*
Yellowtail Kingfish	*Seriola lalandi*
Ocean Reef Perch	*Helicolenus percoides*
John Dory	*Zeus faber*
Deepsea Ocean Perch	Trachyscorpia eschmeyeri
King Prawn	*Melicertus plebejus*
Southern Octopus	*Octopus australis*
Eastern Rocklobster	*Sagmariasus verreauxi*
Latchet	*Pterygotrigla polyommata*
Grey Morwong	*Nemadactylus macropterus*
Cuttlefish (other)	*Sepia* spp.
Giant Cuttlefish	*Sepia apama*
Silver Sweep	*Scorpis lineolatus*
Stingrays/Stingarees	Dasyatidae, Gymnuridae, Myliobatidae and Urolophidae
Flathead (other)	Platycephalidae
Tarwhine	*Rhabdosargus sarba*
Eastern Fiddler Ray	*Trygonorrhina fasciata*
Stout Whiting	*Sillago robusta*
Common Silverbiddy	*Gerres subfasciatus*
Flounders (mixed)	Paralichthyidae and Pleuronectidae
Gould's Squid	*Nototodarus gouldi*
Southern Sawshark	*Pristiophorus nudipinnis*
Sixspine Leatherjacket (Reef)	*Meuschenia freycineti*
Balmain Bug	*Ibacus peronii*
Australian Salmon	*Arripis trutta*

Tailor	*Pomatomus saltatrix*
Sweetlip (mixed)	Haemulidae
Banded Wobbegong	*Orectolobus halei*
Fishes (mixed)	Pisces
Bigeye Ocean Perch	*Helicolenus barathri*
Eastern Orange Perch	*Lepidoperca pulchella*
Mackerel Tuna	*Euthynnus affinis*
Common Blacktip Shark	*Carcharhinus limbatus*
Gummy Shark	*Mustelus antarcticus*
Yellowfin Bream	*Acanthopagrus australis*
Dusky Flathead	*Platycephalus fuscus*
Whitespotted Guitarfish	*Rhynchobatus australiae*
Blue Mackerel	*Scomber australasicus*
Orange Perch	*Caprodon longimanus*
Striped Grunter	*Pelates sexlineatus*
Tilefish	*Branchiostegus wardi*
Bailer Shells	Volutidae
Mulloway	*Argyrosomus japonicus*
Eastern Angelshark	*Squatina albipunctata*
Skipjack Tuna	*Katsuwonus pelamis*
Royal Red Prawn	*Haliporoides sibogae*
Blackspot Goatfish	*Parupeneus spilurus*
Spotted Wobbegong	*Orectolobus maculatus*
Pencil Squid	*Uroteuthis* spp.
Lemon Tongue Sole	*Paraplagusia bilineata*
Ornate Wobbegong	*Orectolobus ornatus*
Sandbar Shark	*Carcharhinus plumbeus*
Eastern Conger Eel	*Conger wilsoni*
Red Mullet	*Upeneichthys lineatus*
Endeavour Dogfish	*Centrophorus moluccensis*

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More information

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Published by the Department of Primary Industries.