TUNA FARM DIVING IN SOUTH AUSTRALIA

David Doolette and Derek Craig

Key Words
Occupational diving, research, safety, training.

Abstract
Since 1990, in response to severe cuts in tuna catch quota, the South Australian tuna fishery has captured fish at sea, then fattened and harvested them at Port Lincoln. Divers are employed in all aspects of this tuna farming operation. In response to an alarming number of diving related injuries, a strategy designed to reduce the number and severity of accidents was implemented in 1995 by the South Australian Department for Industrial Affairs and WorkCover Corporation (the South Australian workers compensation authority) in collaboration with the Australian Tuna Boat Owners Association (representing the tuna farm owners). This strategy focused on raising diving safety to an acceptable occupational standard and resulted in a significant and almost immediate drop in the number of diving related accidents. A research project has been established at The University of Adelaide studying the nature and risk of decompression illness in this industry.

Tuna farming

In the early 1990s, in response to a 67% reduction in catch quota, the tuna fishing industry in Port Lincoln, South Australia began "farming" as a means of value adding to the fish. Through farming, tuna quality can be controlled and the Japanese sashimi market supplied on demand.

Each year, tuna are caught at sea in the Great Australian Bight and herded into semi-rigid tow cages. This cage is towed at approximately one knot towards Port Lincoln. A tow can last two or three weeks. The tuna are herded into stationary pens in the coastal waters near Port Lincoln. The tow cages and the pens are netted enclosures supported by circular pontoons. The tuna are fed on pilchards and during the next one to eight months the fish are carefully hand harvested so as to avoid damage to the flesh. Fish are slaughtered on site, then chilled and packed for shipping.

Tow cages, stationary pens and moorings are constructed, inspected and repaired by divers. Divers monitor the herding and feeding of the tuna and remove any dead fish from the enclosures. Occasionally sharks must also be removed. Divers and surface swimmers assist with the harvesting. The diving activities are relatively high risk.

Figure 1. Tuna pen in coastal water near Port Lincoln. The harvest net is being drawn in. Photograph by Derek Craig.

Dives are strenuous and often involve live boating and blue water diving. They may occur in adverse sea conditions and in conjunction with potentially dangerous equipment (nets, powerheads, cranes, suction pumps, high pressure jets). The divers are involved in repetitive and multi-day exposures.

Initially, the tuna farming process was developed by fishermen with little knowledge of safe working diving procedures who predominantly employed divers with recreational training. Work procedures were developed without due consideration being given to diving exposure, often resulting in provocative dive profiles with unnecessary multiple ascents. Despite the significant risk of entrapment working in contact with submerged nets, diver's air supply was often unreliable. Air was typically supplied from a petrol motor driven, low pressure compressor. Divers had neither secondary nor emergency (bail out) air supplies.

By early 1995, the Department for Industrial Affairs had raised concerns regarding diving operations with the tuna farming industry. WorkCover Corporation had received claims for 39 diving related injuries (at a total cost to date of over $Aust 1.5 million) and 17 divers had been treated for decompression illness (DCI) at the Hyperbaric Medicine Unit at the Royal Adelaide Hospital.

State government strategy

The Department for Industrial Affairs and WorkCover Corporation implemented a joint intervention strategy designed to improve tuna farm diving practice. The foundation of this strategy was to apply appropriate parts of the occupational diving standard (AS2299-1992) to tuna farm diving. Between February and December 1995 a series of on site audits of diving operations were conducted, training sessions were held for divers, supervisors and employers and assistance was given in developing safe operating procedures. With the co-operation of the employers, the Australian Tuna Boat Owners Association and the divers, the strategy produced a significant reduction in the number, severity and cost of injury claims. Despite the success of the strategy, the tragic diving death of a fisherman without diving training on a tuna farm in March 1996 served to highlight the disparity which continued to exist between the best and worst diving practices. In response the Government introduced the Approved Code of Practice for Tuna Farm Diving based on AS2299 - 1992 (gazetted 24 March 1997).

Since the implementation of the strategy and the introduction of the Code there has been an overall improvement in diving practice. All divers now have occupational training. Port Lincoln now has an occupational diver school accredited under the Australian Diver Accreditation Scheme. Divers use positive pressure full face masks, voice communications, surface supplied bottled gas with backup supply and bail out. Diving practices and equipment allow efficient diving procedures. For instance, a single diver with voice communication can direct the drying up of a net to allow harvest of fish from the surface. Many of the diving operations are now run very professionally and this is reflected in the recent safety performance.

Longitudinal health survey

Another strategy has been the introduction of a research project at the University of Adelaide, funded by WorkCover Corporation, investigating decompression risk and outcomes of tuna farm diving. One aspect of this research project is a longitudinal survey of the health of tuna farm divers. The objectives of this study are to collect objective diving exposure data and daily health data from tuna farm divers, to identify a decompression model that fits this data and to produce a computer-based decompression planning tool for tuna farm diving.

To collect diver health information and to identify DCI in the field, a psychometrically sound, self-administered brief health survey for daily use was needed. No such instrument has been reported in the literature so a single page, 10 item diver health survey has been developed. Seven items were developed from symptoms typical of DCI and from the prevalence of symptoms in those tuna farm divers presenting with DCI at the Royal Adelaide Hospital. Two items cover time of onset of any symptoms and general perception of health. Responses to each of these nine items is chosen from four semantic anchors representing scores of 0 through 3. One additional item supplies a brief history (name, date, number of dives, and hours since last dive) and there is space for unsolicited comments.

This diver health survey has now had extensive use in the tuna farming industry with over 250 surveys returned in 1997. Data is being collected to validate this survey including surveys completed by divers subsequently diagnosed with or without DCI at the Hyperbaric Medicine Units at the Royal Adelaide, Prince of Wales and Alfred Hospitals and surveys completed by non-diving tuna farm workers. So far, ten divers diagnosed with DCI have returned diver health surveys with a score of 10 ± 3 (mean $\pm$ SD) significantly different (t-test for independent samples, $p<0.0001$) from the first 100 tuna farm diver health surveys with a score of 3 ± 2 (mean $\pm$ SD), these latter presumably from divers without DCI. The area under the receiver operating characteristics curve (sensitivity versus 1-specificity) of this same data set is 0.97 indicating the diver health survey discriminates well between DCI and non-DCI; discriminating power improves as the area under the curve approaches unity. This curve also establishes the diver health survey cut-off score for DCI as 7.

Objective diving exposure data is obtained from dive depth/time profiles down loaded from diver decompression computers or recording watches. Diver heath surveys and dive profiles are managed using purpose designed database and analysis applications for reading dive profiles, matching health and exposure data, and analysis and reporting of probability of DCI. The probability of DCI is estimated using a linear-exponential kinetics (LE1) probabilistic decompression model[1] for initial feedback of higher risk (>0.01 probability of DCI) exposures to the tuna farming industry. The eventual aim of this study is identify a model of best fit to tuna farm diving exposure and health data using non-linear regression techniques.

Initial data collection from 17 divers occurred during 1997. Health surveys data and dive profiles were matched for 124 days of diving (187 dives). These included 67 single dive days and 57 repetitive dive days. 80% of exposures occurred in multi-day diving sequences of two to five days. The maximum depth of dives ranged from 3.7 to 22.4 m and total daily dive duration ranged from 4 to 190 minutes. All diving was within DCIEM air diving decompression limits. One dive resulted in serious DCI and retrieval to the Hyperbaric Medicine Unit at the Royal Adelaide Hospital. Four additional health surveys reported possible DCI (score ≥7).

The probability of DCI for all dives according to the LE1 model was 0.006 ± 0.003 (mean ± SD), 0.0006 - 0.0139 (range). Nine days exceeded 0.01 probability of DCI, all these were repetitive dives to 21 m. This prompted an examination of the probability of DCI for repetitive dive exposures (0.008 ± 0.002, mean ± SD) versus single dives (0.004 ± 0.002, mean ± SD); these were significantly different (t-test for independent samples, $p < 0.0001$). However, this difference is apparently a result of deeper and longer diving exposure on repetitive dive days compared to single dives. On repetitive dive days the maximum depth of the deepest dive was 19.7 ± 2.9 m (mean ± SD), 10.7 - 22.4 m (range) and the combined time underwater was 44 ± 38 minutes (mean ± SD), 15 - 190 (range). In comparison, single dives were to a maximum depth of 17.5 ± 3.9 m (mean ± SD), 3.7 - 22.3 m (range) and dive duration was 33 ± 25 minutes (mean ± SD), 5 - 105 (range).

Summary

Tuna farm diving has evolved from an industry based on recreational divers to one based on occupational divers. The early experience of this industry with diver injuries illustrates the importance of adopting appropriate diving training and procedures. Historically, other fishing industries have experienced similar problems when developing diving capabilities. Future aquaculture industries, government and the diving community at large have a responsibility to break this cycle.

The longitudinal survey of health of tuna farm divers has developed instruments for diver health surveillance in aquaculture industries. These allow feedback to the tuna farm industry on the prevalent diving practices and outcomes and can be used to estimate the risks of tuna farm diving.

References

1 Thalmann ED, Parker EC, Survanshi SS and Weathersby PK. Improved probabilistic decompression model risk predictions using linear-exponential kinetics. *Undersea Hyperb.Med.* 1997; 24: 255-274.

David Doolette, PhD, is a physiologist attached to the Hyperbaric Medicine Unit, Department of Anaesthesia and Intensive Care, Royal Adelaide Hospital, the University of Adelaide, North Terrace, Adelaide SA 5000 Australia. He has been a member (No 1310) of the Cave Divers Association of Australia since 1984. Phone +61-(0)8-8303-5757. Fax +61-(0)8-8303-3909. E-mail ddoolett@medicine.adelaide.edu.au .

Derek Craig is Inspector of Diving for the Department for Industrial Affairs, PO Box 465 Adleaide, South Australia 5093.

ROYAL AUSTRALIAN NAVY MEDICAL OFFICERS' COURSE IN UNDERWATER MEDICINE

November 22nd to December 3rd 1999

The course concentrates on diving physiology, fitness to dive, and emergency management of diving injuries. Practical involvement includes opportunity to dive with different types of equipment and a recompression chamber dive.

The course fee for 1998 was $1,330.00. The 1999 fee is expected to be about the same but is yet to be determined.

For information or to enrol contact

Officer in Charge
Submarine and Underwater Medicine Unit
HMAS PENGUIN, Middle Head Road
Mosman, New South Wales 2088

Tel: (61) 2 99600333 Fax: (61) 2 99604435
E-mail : Robyn.Walker.150150@navy.gov.au