

## Final project report

<i>Project ID</i>	2003/11.4
<i>Title</i>	On the use of acoustic tomography methodologies to monitoring the oceanic processes variability in Antarctic regions.
<i>Principal investigator</i>	Paola Picco
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<i>Duration</i>	2 years
<i>Assigned funding</i>	100.000,00 Euro

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## Activities and results

This research addressed a feasibility study for a remote monitoring system based on acoustic tomography to be used in antarctic regions. The analysis of data collected during PNRA oceanographic campaigns provided the environmental scenarios and the oceanographic processes to be successfully monitored by means of acoustic tomography and the appropriate information and data to initialize the tomographic processor. The case studies regarded High Salinity Shelf Water formation process in Terra Nova Bay polynya.

The simplified but realistic environmental scenario considered a 1000 m deep area with a flat bottom. The dense water formation area was defined by a strong vertical salinity gradient in the surface, while in the areas outside, temperature and salinity were considered constant in depth leading to an almost linear increasing sound speed profile. At this stage of study, the possible presence of ice layer covering the area is not expected to have any significant effect on the propagation prediction, so it was not considered.

Simulations were carried out with a beam model (Bellhop) which is well suited for active sonar modelling and ocean acoustic tomography in a range dependent environment.

Each simulation involves the use of an acoustic source and a receiving station (tomographic pair) consisting of a vertical array of hydrophones.

By measuring the travel time relative to different scenarios, the analysis aimed at understanding if the detection of the oceanographic phenomenon is feasible. In particular, the study aimed at determining the best compromise between acoustic frequencies, sensors number and geometrical configuration, in order to achieve the desired spatial-temporal resolution useful to detect the presence of dense water masses. An acoustic system configuration consisting of an acoustic source transmitting a pulse with a carrier frequency of 10 kHz, and of a receiving array made of 6 hydrophones resulted to be appropriate, while the minimum size of detectable Dense Water Mass is 0.5 km. In particular, the conducted sensitivity study evidences that the measure of travel time of acoustic rays can be successfully exploited to detect the presence of a dense water mass in a polynya area

Acoustic tomography thus provides "images" of wide areas in the inner ocean for long periods and with an high temporal resolution; in addition it permits to reconstruct the sound speed field even in the upper layers where direct measurements cannot be performed as instruments are at risk of damage. It can then be consider a powerful mean of observation that well integrates conventional in situ measurements. Preliminar investigation on the applicability of this methodology in Terranova Bay polynya demonstrated that it is able to resolve the vertical structure of water column with a good precision.

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## Products

### A – papers in scientific magazines

1. Buffoni G., Cappelletti A., Picco P., 2002: An investigation of thermohaline circulation in Terra Nova Bay Polynya. *Antarctic Science*, 14 (1), 83-92

## Programma Nazionale di Ricerche in Antartide (PNRA)

2. Palmese M., A. Bozzo, S. Jesus, J. Onofre, P. Picco, and A. Trucco, 2002: "Observation of Acoustical Signal Fluctuations by Time-Frequency Analysis Methods," *Acustica united with Acta Acustica*, vol. 88, pp. 653-657, 2002.
3. de Marinis E., Picco P., Meloni R. 2003: Monitoring Polynyas with Ocean Acoustic Tomography: a feasibility study in Terra Nova Bay. *Antarctic Science* 15 (1) 1-13
4. Jesus S.M., Soares S., Coelho E., Picco P. 2006: An experimental demonstration of Blind Ocean Acoustic Tomography. *JASA*, 119 (3) 1420-1431
5. Caiti A., Palmese M., Picco P., Trucco A. 2007: Monitoring antarctic water circulation by ocean acoustic tomography: a sensitivity study. *Theoretical and Computational Acoustics '07*. M.Taroudakis, P.Papadakis eds, pp.39-46.
6. Picco P. Cappelletti A. 2009: Upper layers currents and surface forcing in Terra Nova Bay. Submitted to *Antarctic Science*

### B – book chapters

1. Jesus S.M., Soares S., Onofre J., Coelho E., Picco P. 2002: Experimental testing of the blind ocean acoustic tomography concept. In: *Impact of littoral environmental variability on acoustic predictions and sonar performance*. Pace N.G & Jensen F.B. eds. Kluwer Academic Publisher. 433-440

### C - proceedings of international conferences

1. Palmese M., A. Bozzo, S. Jesus, J. Onofre, P. Picco, and A. Trucco 2002: Observation of acoustical signal fluctuations by time-frequency analysis methods. In *Proceeding of the sixth European Conference of Underwater Acoustics*. A. Stepanowski ed. 755-760
2. P. Picco, A. Trucco, M. Palmese, R. Meloni, 2004: "Sound Speed Variability and Oceanographic Processes in the Ross Sea (Antarctica)," *Proceedings of the 7th Europ. Conf. on Underwater Acoustics*, Delft (The Netherlands), paper no. 235, 6 pp.
3. Picco P. Cappelletti A., Meloni R. 2005: An analysis of one year long time serie of ADCP measurements in Terra Nova Bay. *III International Conference of Ross Sea Oceanography, Venezia, Ottobre 2005*
4. Cappelletti A., Picco P., Meloni R. 2006: A Long Time series Analysis of Temperature, Salinity and Currents in Terra Nova Bay (Antarctica). *EGS - AGU - Joint Assembly*, Wien April 2006
5. Picco P., Meloni R., Trucco A., Palmese M. 2006: " An analysis of sound speed variability in Terra Nova Bay (Ross Sea, Antarctica)" *Proceedings of the 8 th Europ. Conf. on Underwater Acoustics*. S. Jesus & O. Rodriguez Eds, Vol.1, 421-426
6. Cappelletti A., Picco P., Esposito P., D. Martucci, G. Fusco, R. Meloni 2007: Ten years of currentmeters measurements in Terra Nova Bay (Ross Sea, Antarctica): data set presentation. *XXIV IUGG General Assembly*
7. Picco P. Cappelletti A., Meloni R. 2008: Long-term currents variability in Terra Nova Bay (Ross Sea, Antarctica): a climatological analysis. *SCAR S.Pietroburgo*, 8-11-June 2008

### D – proceedings of national meetings and conferences

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### E – thematic maps

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### F – patents, prototypes and data bases

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### G – exhibits, organization of conferences, editing and similar

1. Workshop "Acoustic tomography in Antarctica : project presentation and results" ENEA S.Teresa, November, 30 2007

### H - formation (PhD thesis, research fellowships, etc.)

2. Maria Palmese DIBE, Università di Genova. Post-doc fellowship
3. Esposito Paola, 2006: Analisi di serie correntometriche in Baia Terra Nova (Mare di Ross, Antartide) e simulazioni di circolazione indotta dal vento Tesi di Laurea Specialistica in Scienze Ambientali, Università degli Studi di Napoli. A.A. 2005/06, 121 pp.
4. Martucci Daniela, 2006: Analisi delle caratteristiche oceanografiche in Baia Terra Nova (Antartide) finalizzata alla progettazione di un esperimento di tomografia acustica. Tesi di Laurea Specialistica in Scienze Ambientali, Università degli Studi di Napoli. A.A. 2005/06, 130 pp.
5. Traverso Federico, 2007: Studio di un sistema acustico subacqueo per il monitoraggio della formazione di acqua densa in Antartide. Tesi di Laurea, DIBE, Università di Genova, AA 2006/07, 87pp

**Research units**

ENEA Marine Environment Research Centre S.Teresa – La Spezia (I)  
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Prrincipal investigator: prof. Andrea Trucco

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