

## ***ATOC: Sound Policy or Enviro-Vandalism? Aspects of a modern media-fueled policy issue***

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*The recent debate on the proposed Acoustic Thermometry of Ocean Climate (ATOC) experiment has revealed sharp incongruities in approach by the public, their elected representatives and the scientists behind the program. It appears that much of the current outcry has arisen as a by-product of rapidly evolving environmental attitudes and information technology, to which none of the key parties to the issue have yet fully adjusted. The process of dissemination and assimilation of scientific information that guides the progress of issues of increasing complexity is no longer in equilibrium with evolving technology. Specifically, it is argued that there are two crucial components to an incipient instability in public and official response to emerging scientific policy issues: 1) The extremely rapid and broad dissemination of information made possible by the information highway and 2) The great pressure to paraphrase and attempt to formulate a position without investing the full resources required to adequately comprehend the issues. The result is a socio-economic 'loose cannon' that may seriously hurt innocent and guilty parties alike, but which may also help clear away anachronistic paradigms and provide the flexibility of response required to address Earth's rapidly evolving environmental crises.*

### ***Introduction***

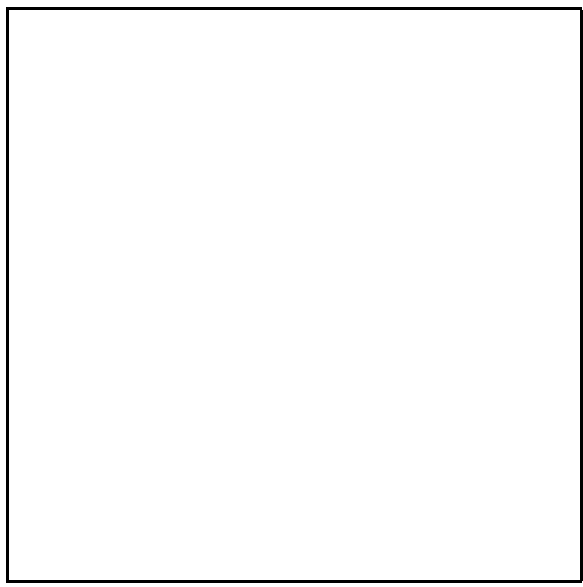
As the developed nations' sense of urgency increases with regard to curtailing the rate of anthropogenic environmental damage many new environmental arenas are becoming of importance to the public at large and hence their elected representatives. One of these relatively new areas is the effect of anthropogenic noise pollution in the oceans. This is a small but instructive arena that currently hosts one particularly hot topic of dispute, the perceived risks and benefits of the Acoustic Thermometry of Ocean Climate (ATOC) experiment. This experiment carries with it a particular irony; it purports to be in the cause of environmental conservation, providing a monitoring facility for suspected Global Warming. More poignantly still, ATOC is funded by the congressionally-mandated Strategic Environmental Research and Development Program (SERDP), that was created specifically to convert former defense budget items into environmentally beneficial products.

The debate has arisen because of collateral effects of the ATOC method for measuring global ocean temperatures. Rather than use conventional thermometers, ATOC employs a particularly elegant and powerful technique based on sound propagation<sup>1</sup>. The physics of sound propagation in the ocean are now quite well-known,

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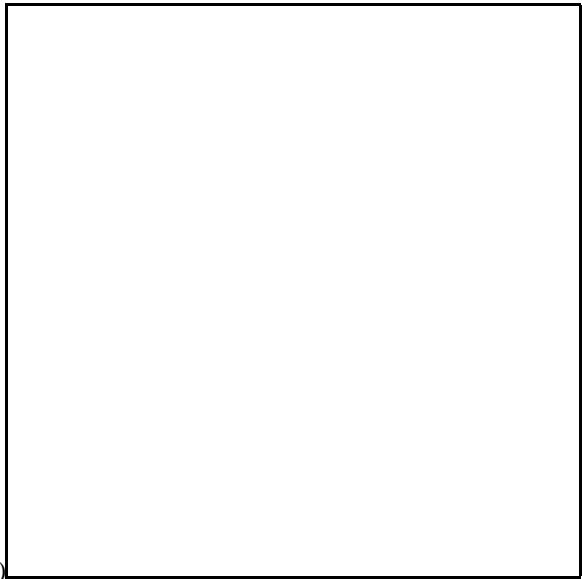
<sup>1</sup>The ATOC method, though much refined, relies on a fundamental aspect of ocean acoustics recognised as

and the dependence of the speed of sound on temperature, pressure and salinity has been determined with great accuracy<sup>2</sup>. Without detailing the pieces of the technological



far back as Leonardo Da Vinci

(Lindsay,



1972)

; The extraordinary ability of small sounds to travel great distances underwater.

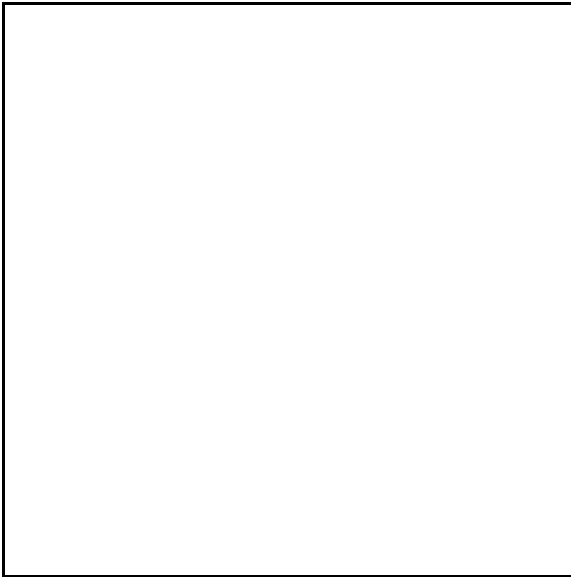
<sup>2</sup>Though minor refinements to the equations for the speed of sound in seawater continue to this day

puzzle, the ATOC team believes that they can measure the travel-time of specially designed sound signals with sufficient accuracy to determine the ocean's temperature over a broad depth range below the surface and with better rejection of local variations than any other current method allows. The only drawback is that ATOC needs to inject some 210 watts of sound power into the ocean, a contribution to acoustic pollution that some marine mammal experts believe may disturb the very inhabitants whose environment ATOC seeks to protect.

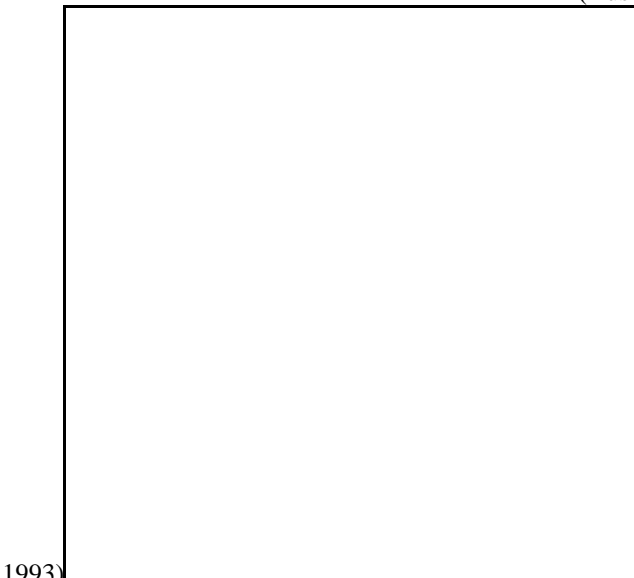
This analysis attempts to present the scientific facts as known to the author, to describe the chronological pathology of the initial slow-burn and subsequent explosive onset of national debate and to draw some conclusions concerning the mechanisms by which the status was reached. While the primary objective here is not to determine the scientific merits of ATOC, a primer in the scientific background is required to appreciate the wider context of the debate.

### *Background Physics of ATOC*

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(Dushaw, Worcester, Cornuelle, & Howe,



1993)

National policies concerning global climate change ought to be based on knowledge made as complete as possible by objective measurement and logical inference, or scientific method. This, at least, is the way we claim to do business. Leading global climate modellers agree that meaningful estimation of climate change must include the effect of the oceans, which provide a huge thermal inertia for the planet. At present it is uncertain exactly how fast extra heat in the atmosphere will be absorbed by the oceans. Unless the global climate is modelled as a coupled ocean-atmosphere system, and the oceans are modelled at least as accurately as the atmosphere, then we can have no confidence in model predictions. It is important to make the distinction between detecting and modelling the process of global warming. Detection is valuable in that it provides the motivation to do something positive about addressing the problem but is not useful beyond that. Only if we can model the process and validate our models against comprehensive observations can we make trustworthy predictions about the most effective measures to take, and the impact of proposed change in anthropogenic behaviour. In this context, it matters not whether global warming (if occurring) is anthropogenically-driven or part of a natural cycle; warming will severely impact human activities and we need to know if we can ameliorate the changes.

How does one go about measuring the oceans' temperature? Spot measurements, even a great number of them, are vulnerable to local variability. The oceans are dynamically very active, with spatial structures on the scales of millimeters to thousands of kilometers, a range of over 9 orders of magnitude (Potter & Warn-Varnas, 1990) . Temporal scales range from less than a second at the smaller spatial scales to at least several years<sup>3</sup>. This wide range of variability makes it extremely difficult to make accurate observations of large-scale underlying trends, such as global warming. Currently, the only methods with sufficient coverage and resolution derive from satellite observations of the sea surface and Arctic ice cover. Satellite altimeter data (which gives sea surface height and indirectly temperature) is presently too imprecise. Arctic ice cover data provide insufficient information about temperate latitudes for model validation, though warming detection may be within their scope. Sea-surface temperature measurements are just that; the electromagnetically conductive ocean limits such data to the very surface skin of the sea. The oceans are some 4000 m deep, how are we to measure the rest? Large numbers of autonomous drifting thermistor chains and satellite altimeters may provide the answer in the future, but these techniques have some way to go before meeting the observational demands of a verifiable coupled ocean-atmosphere model.

This is where the ATOC experiment could help. It has long been known that sound can be made to travel in a bounded region some 2000 m deep centered at 1000m or more below the sea surface in moderate latitudes, by means of a naturally occurring sound channel that acts as a lens to guide sound energy without appreciable loss (Ewing & Worzel, 1948) . This sound channel arises as a result of two competing effects on sound speed; temperature decrease and the pressure increase with depth in the ocean. Sound is refracted downward near the surface, and upward from great depths. The result is that sound energy can propagate great distances with little loss from interaction with the surface or bottom boundaries. A moderately powerful transmitter can thus inject sound into this channel that can be received at great distances. Noise injected near the surface, such as from ships, also makes its way into this channel, but less efficiently than if the source is at depth. By measuring the travel time between a source and receiver at

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<sup>3</sup>Ignoring very long-term cycles such as ice ages, the "El Niño" events (which occur quasi-periodically every few years) are one of the longest period cyclical ocean phenomenon, and still poorly understood.

precisely known locations, the average sound speed of the intervening ocean can be determined. In fact, the arrival structure of the sound is complicated by the lens of the ocean, and if the sound is designed with care this can be used to provide an average temperature profile over the entire upper half of the ocean. A critical component of this method is the signal processing technique known as 'pulse-compression' This is a method by which the required energy in a signal can be spread over a long time and, providing an exact knowledge of the pulse sequence is known, reconstructed at the receiving end. This permits the reception of signals that would otherwise be completely obscured by background noise. Given that a minimum signal energy is required to be heard at great distances, even via the efficient sound channel, the technique permits this energy to be spread over several minutes, greatly reducing the transmitted sound level at the expense of increasing the time for which it transmitted.

Thus was born the idea of the ATOC project, initially to place two transmitters at key locations in the Pacific and to listen for transmissions from these sources at many more sites near the ocean margins. The Project is the brain-child of Professor Walter Munk (Munk & Forbes, 1989) of Scripps Institution of Oceanography, is to cost at least \$35 million and involves the collaboration of over 12 Universities and research laboratories in 8 countries. Many of the listening posts would be provided by the US Navy, who had installed suitable sensors at great cost for their own purposes, now largely overtaken by the collapse of the Former Soviet Union. In this way the ATOC project not only used funds formerly directed towards the military, but in addition made valuable use of the US Navy's considerable hardware assets. By measuring the average temperature profile along many intersecting transects in the Pacific, the ATOC project was intended to provide a prototype measurement of exactly the reliable ocean temperature data that the modellers so badly require.

### *The Heard Island Feasibility Test*

**B**efore ATOC, there was the Heard Island Feasibility Test (HIFT) in 1991. The HIFT was a one-shot test to see if signals could be received over the required distances at the frequencies that would need to be employed (Baggeroer & Munk, 1992) . Both ATOC and the HIFT are natural progressions from over a decade of acoustic tomography experimentation which typically used sources of 185 dB to probe the oceans (Worcester, Cornuelle, & Spindel, 1991) . The HIFT used source powers up to 221 dB (the decibel, or dB, is a logarithmic measure of energy ratios, so 221 dB is 4000 times more powerful than 185 dB) to maximise the chances of receiving a clear signal. Shortly before commencing the test, however, the scientific team became aware that the 1972 Marine Mammal Protection Act (MMPA) required them to first obtain a permit from the National Marine Fisheries Service (NMFS) to 'take' marine mammals. The word 'take' in the MMPA has a specific (and some would say bizarre) meaning, which turns out to have had no small impact on subsequent developments. The meaning of 'take' in the MMPA includes not only taking by literal killing, but also harassment, and is interpreted to include any significant change in behaviour of a marine mammal. The requirement for a permit came as a complete surprise to the HIFT researchers, who had been conducting similar (if much smaller) tomographic experiments for over a decade against a background of still more experiments of similar or greater source strengths. The HIFT applied, following advice from the NMFS, to 'take' the entire mammal population in the region surrounding the source (several hundred thousand marine mammals) even though no physiological damage was expected. Additionally, on-site observations were required near the location of the source to determine any adverse effects on marine mammals.

The NMFS permit process normally takes about a year, and it appeared that a permit would not be issued in time for the programmed test to proceed. As a last resort, some high-level pressure was brought to bear to encourage a speedy review of the permit application and a permit was finally issued, barely in time for HIFT. This solved the immediate problem and allowed the test to proceed, but lay the groundwork for future permit difficulties. Not only was there resentment over the issue of perceived political pressure, but the mammal observational program was designed as an afterthought and with insufficient baseline data and coverage to impress marine mammalogists who opposed the HIFT. The very difficult conditions prevalent in the southern ocean exacerbated the observational program and the results were inconclusive with respect to behavioral changes, though no animals appear to have suffered physical harm (Bowles, Smultea, Wursig, DeMaster, & Palka, 1993).

Following the successful HIFT, the scientific team designed ATOC with a maximum of 195 dB (less than 1% of HIFT's signal output power) relying on the pulse-compression signal processing technique to recover the signal from the background noise at great distances. This would not only make the transmitters less expensive, but would hopefully allay concerns from environmentalists who had been opposed to HIFT. In addition, the ATOC sources would be placed at much greater depths than for the HIFT, further reducing impact on the biologically rich surface waters. It was thus that in November 1993 the ATOC team applied once again to the NMFS for a permit. Again following NMFS advice the application indicated a 'take' of a significant portion of the entire Pacific marine mammal stock, in effect a guess at the total number of animals expected to be affected in the worst possible scenario.

Despite the earlier environmentalist opposition to HIFT, the ATOC team did not expect further difficulties because of the much reduced power output, the greater source depth and the greatly expanded mammal observational program. Some \$3 million dollars had been budgeted for this, headed by internationally respected marine mammal researchers and overseen by an external panel of experts. The observational program was started 2 years before the sources were due to be turned on, providing both a sufficiently comprehensive study and baseline data to satisfy critics, or so it was thought. What the ATOC project team failed to appreciate was that the general public had developed a very strong affinity to marine mammals which answered more to emotional than to rational argument, as capitalised and reinforced by Hollywood in 'Free Willy'. That which engages public interest, sells newspapers.

### *Chronology of the early debate, The slow-burning email fuse*

On February 2, 1994 a posting was made on the 'marmam' (marine mammal) network<sup>4</sup> by Weilgart and Whitehead (W&W), two experienced population biologists, warning that ATOC planned to transmit sounds 10 million times louder than that known to cause pain in human airborne hearing (120 dB). The posting also mentioned Newfoundland humpback whales found with shattered ear bones, damage W&W thought had occurred at sound levels less than the ATOC sources. The message was a remarkably calm and rational appeal for dialogue, considering the level of devastation described. Unfortunately, the predictions of severe physiological damage were in error. Specifically, the reference to human pain threshold is inappropriate since hearing

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<sup>4</sup>Full transcripts of this forum can be obtained by sending a message "subscribe marmam <name>" where <name> is your full name to listserv@uvvm.uvic.ca. Once registered, the listserver can be asked for archived messages; start by sending a message to the listserver which reads "info database".

mechanisms depend on energy coupling rather than pressure, and should be scaled down by a factor of approximately 1 million when comparing air and waterborne sounds due to differences in reference values, densities and sound speeds in the two media (Potter, 1994) . Secondly, the Newfoundland humpback incident is understood by the hearing expert who examined the whales to have occurred as a result of non-linear shock waves from underwater explosions some 1 million times greater than the ATOC source would produce (Ketten, 1994) .

The following weeks saw sporadic email activity on this network (Fig. 1) from W&W, senior ATOC researchers attempting to quell fears and a widening circle of newcomers who were mostly very concerned about the predicted damage. In addition, there were several postings from correspondents who said that they had passed on the original alarm to other networks. ATOC researchers stated that the ATOC source was much less noisy than a large ship in the ATOC frequency band in addition to addressing other points. On 15 February W&W issued a posting with a noticeably stronger and more rhetorical tone, suggesting a defense conspiracy that undermined ATOC scientific credibility. By the end of February, W&W assumed the role of opposition vanguard, issuing an outright attack on ATOC, a noticeable shift from the original call for dialogue. Later W&W postings repeated the Humpback error, stated that the sources would cause permanent hearing damage in a radius of some 180 m (a much smaller range than originally thought but still inaccurate)<sup>5</sup> and suggested that the ATOC project had been kept deliberately quiet, with the permit application hurried along to minimise exposure to adverse comment. The expectations of widespread physical harm were compounded by the NMFS permit request indicating a “take” of over 500,000 animals that was interpreted by some as “kill”. The emotive and aggressive stance placed W&W in a very forward and polarized position from which it became progressively more difficult to retract, even if they had so wished. Perhaps W&W felt under personal attack from the ATOC rebuttals. Certainly they felt entrapped in a “David and Goliath” conflict, a term they used themselves in a subsequent mailing. In any event, W&W moved from a position of requesting rational debate to an outright fight to stop ATOC.

This is not the place to catalogue a blow-by-blow account of the bulletin battle although as one contributor said “The story of ATOC, the press and the net would make a great research project for the spread of misinformation...”. Suffice to say that the original warnings of widespread physiological damage were flawed and that W&W felt obliged to take an ever more forceful position as these claims were countered. The sense of pressure was certainly exacerbated by the short time-scale for public comment, made worse still by the lack of ATOC public relations preparation. The effect of the debate may have been steadily spreading to a wider audience, but there is no evidence of an explosive increase of interest until the end of March (if at all on this network), as shown by the histogram of marmam traffic in Fig. 1. Sufficient concern was raised, however, to motivate several people to formally request the NMFS for a public hearing, something that had never previously been granted for a MMPA permit case. The NMFS responded by scheduling a public hearing at their offices in Maryland, just outside Washington D.C., for 22 March.

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<sup>5</sup>The indications are that no permanent damage results at intermittent levels up to 150 dB but temporary hearing threshold shift may occur, such as we might experience after going to a noisy bar.

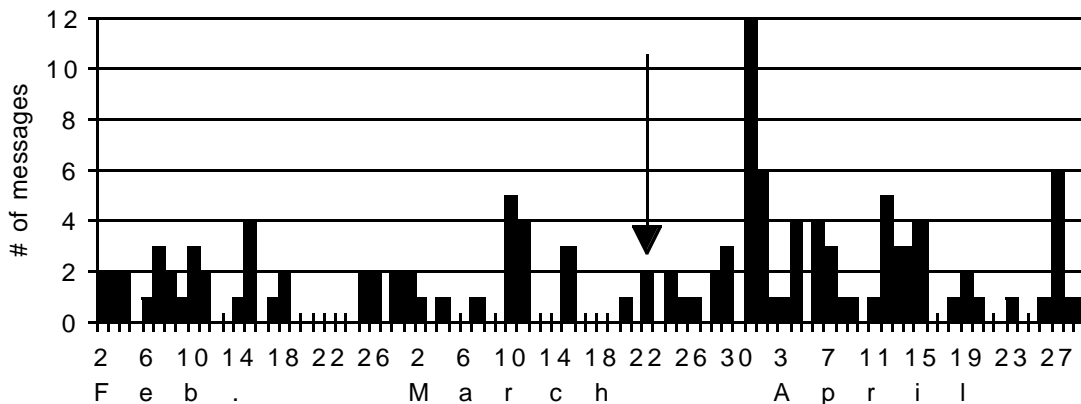


Figure 1.  
 Histogram of ATOC traffic on the marmam Internet.  
 The vertical arrow indicates the publication date of the syndicated L.A. Times article, the “PseudoScience” posting and the NMFS Public hearing.

### *The first NMFS Public Hearing*

At the time of the hearing on March 22, the ATOC team felt that the opposition was based purely on simple errors of understanding and that all they need do was to present their case fully and honestly and the problem would be resolved. This illustrates both a naiveté of public relations and a failure to appreciate the many issues being raised other than physiological damage. At the hearing, W&W made their case, still predicting physiological damage, but also pointing out the possibility of pervasive psychological impact. The ATOC team made their presentations and a number of independent researchers also gave depositions, including Ketten (the hearing expert responsible for the Humpback whale observations) and this author<sup>6</sup>. By the end of the meeting even W&W were satisfied that physiological damage was not the prime issue<sup>7</sup>. So the story might have fizzled there, were it not for an inflammatory interview provided by Weilgart the previous day to the Los Angeles Times, and a curious coincidence in time.

### *Ignition*

In the days preceding the first public hearing, Weilgart repeatedly telephoned the editors of the L.A. Times, requesting coverage of the ATOC issue. Finally a staff writer from the San Francisco branch, Richard Paddock, was assigned the story and instructed to produce an article on the Monday, in time for the Tuesday hearing. The ATOC team were either on-route to the hearing or taking advantage of the University-wide three-day weekend on the Monday that Paddock called for information. In any event, the L.A.

<sup>6</sup>Full copies of the transcript and all written depositions may be obtained from the Permits Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910.

<sup>7</sup>Personal communication with W&W, 22 March 1994.

Times article that ran on Tuesday contained no quotes from Scripps. The front page story was entitled “Undersea Noise Test Could Risk Making Whales Deaf” based on an interview with Weilgart, and repeated the incorrect comparison with airborne sound and predicted widespread hearing damage and mortalities. In addition there is the outlandish quote “We are invading an ocean habitat that so far has been untouched by man”, a misconception so naive as to beggar belief. The truth is much more alarming; most of the world’s oceans are already dominated by anthropogenic noise, mostly from commercial shipping but also including seismic surveying, offshore oil and gas platforms, sonar systems, testing and commercial explosions, to name but a few. It is not clear why Weilgart provided such inaccurate statements to the press, after the marmam debate had cast substantial doubt on the issue of physiological damage and had included a great deal of information on ocean acoustics from several professionals in that field. Weilgart probably felt both inextricably committed and under powerful attack from the ‘big money’ in ATOC and defense interests, perhaps believing that the marmam forum was falling under the control of ATOC-controlled misinformation.

Whatever the motivation, the result was the explosion of concern that has made the ATOC debate infamous. The article was widely syndicated and spawned several others in smaller papers and at least one spectacularly successful “shot from the hip” response from a distraught networker entitled “PseudoScience Marches On” who believed that the word “take” was ATOC’s euphemism for “kill” and therefore concluded that ATOC expected over 500,000 animals to die. The author predictably lambasted the ATOC program, calling it “one of the most astoundingly stupid and potentially destructive experiments it’s ever been my displeasure to read about in advance” and incited the reader to “Call everybody you can think of, and then ten more you can’t. You can use E-mail and Congressgrams...” and perhaps the most crucial sentence “Please feel free to redistribute this message -anywhere- you want”. And they did. The ATOC faxes at the NMFS office alone were piled four feet high<sup>8</sup>. Petitions were begun everywhere from campus cafés to surf shops and protest flooded into elected representatives’ offices. The ATOC team were away in Washington and did not get back to California to respond until several days later, by which time the damage was done.

What really set the issue afire? The L.A. Times article was a crucial ingredient, since without it PseudoScience would not have been written, and the syndicated versions spread the alarm to the widest audience. But the article itself (and its spin-offs) did not decry the ATOC plan nearly so strongly as PseudoScience, or incite protest. The conclusion is that PseudoScience played a significant role in the resulting avalanche of protest to NMFS and elected official offices. The impact was made more explosive by the pressure of timing which appeared as if the public hearing was being slipped by without a mature assimilation of the facts. PseudoScience was received by this author from four independent sources. Although W&W have been criticized for promulgating inaccurate protest<sup>9</sup> on the marmam forum, Fig. 1 shows only a mild increase in traffic on this network. Their input to marmam failed to generate the explosion of protest found elsewhere, probably because its readers had been exposed to aspects of the debate over a longer period and were able to respond more rationally. The fabulous success of PseudoScience appears to have sprung from its propagation as a chain letter across many networks and bulletin boards who were previously unaware of the ATOC debate and who had no time in which to assimilate the full picture before firing off their protest. The Paddock article and PseudoScience gave ATOC opposition a critical mass and inertia of

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<sup>8</sup>Personal communication from Carol Fairfield, NMFS.

<sup>9</sup>W&W took considerable heat on the network, to the extent that Weilgart withdrew from the marmam discussion, clearly stung and referring to career risk. Nevertheless, W&W remain committed and active campaigners to stop ATOC.

its own. Ironically, they appeared the same day that the demon misconception of killing marine mammals was finally laid to rest, at least among the central participants of the debate. Petition gatherers still garner signatures based on the original premise of widespread mortalities and a few papers are still publishing pieces based on the original discredited claims.

The level of broad public interest can be gauged by the histogram of newspaper articles and letters shown in Fig. 2, separated into basically positive, neutral or negative assessments of ATOC<sup>10</sup>. There are only 15 articles in the entire year prior to March 1994. The pervasive impact of the Weilgart interview with the L.A. Times published on 22 March and subsequent fall-out is clear. Most of the articles on 22 March were syndicated repetitions of the original (negative) Paddock piece. The minor peaks around 5-6 and 14-15 April coincide with follow-on articles by Paddock, also widely syndicated, and the Hawaiian hearings respectively.

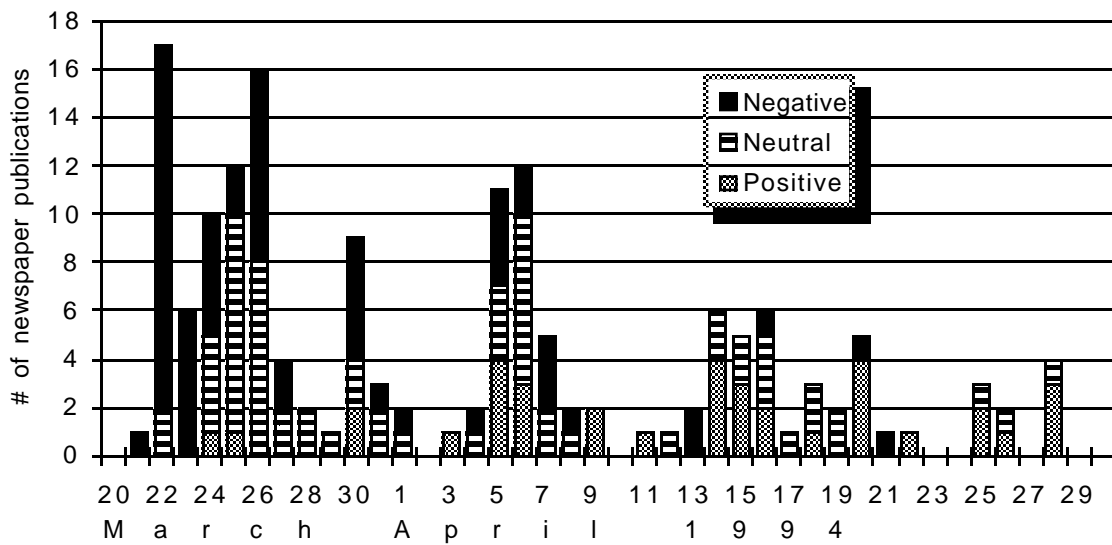


Figure 2.  
Histogram of ATOC newspaper articles.

### *The high-level fall-out*

Apparently as a direct result of the panic brought about by the L.A. Times and PseudoScience, at least two senators (Boxer & Feinstein) were moved to write strong letters of condemnation. The NMFS were buried under a barrage of protest and contacted by several environmental action organizations who were considering pointing their lawyers in the NMFS direction. The NMFS has a legal obligation to enforce the MMPA, and could be successfully sued if it does not. The parent body of NMFS is NOAA, whose Director was requested to make a presentation to Congress, some of whose members apparently indicated that the multi-billion annual NOAA budget might not be approved if the NMFS issued a permit for ATOC. Residents and elected representatives in the two areas where the ATOC sources were to have been installed

<sup>10</sup>Press cuttings provided by the Director's office, Scripps Institute of Oceanography.

were mobilized and began immediate resistance. As a result of this pressure, the NMFS agreed to schedule three further hearings on ATOC. The first two follow-on hearings in Hawaii drew openly hostile crowds, already completely polarized on the issues by the negative press, though much of the opposition argument was based on far more mature considerations than at the earlier Maryland hearing. Two Congresspeople (Mink & Abercrombie) who had called for further hearings submitted a letter of stinging attack on ATOC and the NMFS conduct of the permit application process. This letter specifically attributes the source of their concerns to newspaper articles and admits that “at this late time we are caught by surprise and without adequate time to investigate...”. Badges proclaiming “Ban the Boom” had been fabricated in bulk and were handed out. One of the more extreme responses compared ATOC to the Holocaust, and in the mind of the author the Third Reich came second in this unenviable competition. A briefing was even made to Vice President Gore. Remember, all this based on a sensationalist newspaper article, founded on an interview with a postgraduate researcher.

### *So what are the real issues?*

**T**he fact is that the ATOC sources are likely to cause observable reactions within 30 km range, and may cause temporary hearing threshold shift within a few hundred metres. Further away, it might be heard by marine mammals above the background noise as far as 1000 km or so range when activated (at a 8% duty cycle). This sounds appalling, and perhaps it is, but no more so than a single large ship that might ply the oceans 24 hours a day, and which can also be heard at comparable distances. ATOC would contribute about 0.001% extra noise in the oceans, and shipping alone is a far more energetic polluter over a broader frequency band. The problem is not so much that ATOC will inject unprecedented new levels of annoying noise, as that the public has previously been blissfully unaware of the horrific level to which we have already polluted the oceans with noise from other activities. Ocean acousticians are accustomed to these facts, and react blandly, which further enrages the public who have only just discovered the extent of the issue. Indeed, public awareness of environmental issues in general is still a very young phenomena.

The perception remains that the ATOC sounds might have unknown psychological effects on marine mammals, providing the basis for continued concern. This stems in part from a very comprehensive and thorough report by the Committee on Low-frequency Sound and Marine Mammals of the Ocean Studies Board, National Research Council (Green, DeFerrari, McFadden et al., 1994) . This report makes it clear that very little is known about hearing thresholds and frequency ranges of many marine mammals and that in the majority of cases there is no satisfactory scientific model to predict the effects of low-frequency sound. It is but a small, but crucial, step to assume that the effects will be unknown. This step invokes the assumption that the ATOC sources are a new imposition on marine mammals, as if ATOC were to assault a pristine environment as quoted in the original L.A. Times article. This is far from the case and the public has still to assimilate that fact. The ATOC sounds will be roughly similar to many natural sounds and constitute an additional contribution to the considerable background of shipping and other sources. This does not excuse ATOC from accountability, but it does make it unlikely that there will be any substantial new impact on marine mammals. Interestingly enough, the NAS report concludes that, far from using our ignorance as an excuse to prevent research activities that might adversely affect marine mammals, we should seek to expedite the lengthy NMFS permit process for research applications. The reasoning is that the very mechanisms that have been created

to prevent harassment of marine mammals are hindering our attempts to learn how better to protect them.

There are areas where ATOC ultimately cannot promise anything. It is not guaranteed that the ATOC sources will be heard by marine mammals as similar to other natural sounds and ships, since we do not know the detailed working of their minds. The extremely sparse data on marine mammal hearing and behaviour precludes guaranteeing that **any** additional noise pollution will not trigger substantial damage. The only honest defense is to point out that existing noise has not apparently done so and that ATOC will contribute little extra. This is considered as weak and insufficient justification by some opponents, who are against contributing further pollution in the oceans on principle. To many, the benefits of ATOC have not been demonstrated and even a marginal risk to the environment is unacceptable. The ATOC project itself admits that the experiment may not work, for if it could be guaranteed it would be a demonstration rather than an experiment. Even if ATOC provides the results on ocean temperature that confirm global warming, there is no guarantee that governments or the offending industries will take effective action to reverse the process. Many people already accept global warming as fact, so further demonstration seems unnecessary, particularly if it involves environmental risk.

There are also more specific questions. Why is one ATOC source scheduled to be installed in a Californian marine sanctuary and the other in Humpback breeding grounds of Hawaii?<sup>11</sup> Why are the sources to be turned on at full power from day one instead of starting at a very low level and gradually increasing the power over a period of weeks, or even months? If ATOC really wants to study marine mammal responses, shouldn't the mammal observers have control of the sources? These issues appear to illustrate a marked lack of sensitivity to the environment, and in many people's eyes have discredited ATOC's claims to have designed their experimental plan to minimise the impact on marine mammals. Additionally, although the ATOC sources would contribute very little extra noise to the oceans in total, it would be introduced near the focus of the deep sound channel and travel very far. Thus, although the levels may be low, the effect on deep-diving mammals and deep-inhabiting prey could be much more significant than a simple power calculation would indicate. Finally, ships may be noisy, but they move on. What are the implications for sources that are fixed and transmit for years? Are the sources sufficiently far from feeding, breeding and other important areas? What would be the impact on fish and other prey? To evaluate these genuine issues, acousticians and marine biologists need to sit down and discuss the possibilities rationally, and this is now beginning to happen. The ATOC researchers believe that they can counter these charges, and perhaps they are right. This author is not qualified to judge, even if this were the forum. The risks and benefits both need to be assessed and balanced by experts in the field, a feat unlikely to be achieved to the satisfaction of all due to the considerable latitude in the estimation of both these elements.

Perhaps what we should be asking ourselves is, if ATOC concerns us, what are we going to do about the real noise polluters in the ocean? How much noise is too much? Are marine mammals and other inhabitants near a threshold of collapse under noise and other pollution? Since stopping the world's commercial shipping fleet and geophysical survey vessels overnight is not going to happen, what does constitute a sensible course of action? ATOC has become a lightning rod for environmental concern. The continuing

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<sup>11</sup>Costa, a senior member of the ATOC marine mammal observation effort, proffers several reasons; The requirement for a direct acoustic path, the ready availability of a Navy receiving array to monitor mammal impact, sanctuary guidelines which specifically state that mammal monitoring research is one of its functions and that there already exists an excellent baseline for marine mammal populations and behaviour.

virulence of public opposition to ATOC appears to be a result of inertia, since the basis for the original widespread protest has been discredited. Also, ATOC is easier to stop than commercial shipping, so it provides a more sinkable target. But is that a just reason for stopping a research program that might add to our knowledge of our environment? It seems to me to be a cowardly course of action. If we could apply even a little pressure to the main noise polluters, to get quieting devices made mandatory for US commercial ships' propellers for example, a fractional reduction in the noise output of these vessels would represent a gain many times more significant than killing ATOC.

***What did ATOC do wrong?  
(& what can we learn from these mistakes?)***

Quite apart from issues of potential environmental harm, some people perceive the ATOC project to be arrogant, which drains sympathy for their cause. This has arisen by a combination of the dispassion evidenced by the ATOC researchers about the issues and their failure to prepare the public relations ground before proceeding so deeply into the project. The dispassion is easily comprehended; it is no more than the calmness of a commercial pilot checking his aircraft's systems before take-off. Habituation to the technology and operating environment has de-sensitized these scientists to much of the awe and subsequent fear that is the first response of the newly exposed individual. Besides, scientists take pride in their dispassionate and calm approach, it being considered an advantage in objective evaluation. Newspaper publicity is derided as self-aggrandizement amongst their scientific peers. Nevertheless, at least the commercial pilot is sure to inform his passengers that the aircraft is about to take off, lest the more nervous begin to panic as the aircraft begins accelerating. This the ATOC project failed to do. They decided not to run a widespread public relations effort aimed at keeping the general public<sup>12</sup> briefed, but to get on with flying their particular kite. This approach is the way things used to be done, in the days of the cold war and before the maturing accountability that the public now expects. In these days of ready access to information and communication, even relatively small items are vulnerable to a call for accountability, a de-facto referendum, if the public interest exceeds a critical threshold.

Nevertheless, the claim that ATOC tried to proceed secretly is demonstrably false. Apart from the many lectures and small scientific articles that the ATOC team produced in the preceding year, Scripps Institute of Oceanography sent an announcement describing the project to over 170 media outlets on February 19, 1993 when the \$35 million contract was awarded. This was a major research effort on a topic of great current interest, global warming. The result was a paltry 8 small newspaper articles. Why did it not attract more of the attention that it later suffered from? The answer is simple, the SIO announcement made no mention of whales or the possible environmental impact of their sources. These were issues that the ATOC team felt were tangential to their main purpose, whereas the public see the project from another perspective. Failing to recognise the 'hot buttons' in the public mind carries a great cost. It is not so much that the ATOC team kept quiet; they simply failed to realize the aspects of their experiment that people were interested in listening to.

The former high regard for scientists has been steadily eroded over recent decades by a sequence of technological failures and misrepresentations. The issues surrounding the safety and cleanliness of nuclear power are a prime example. The public has been

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<sup>12</sup>Although Walter Munk alone has made over 25 lectures on the purposes and plans of ATOC, in addition to many short articles in scientific circles.

taught to question authority and to distrust the reassurances of scientists. This self-empowerment has occurred in parallel to a burgeoning awareness of our environment, planet Earth. In a few decades attitudes have evolved from considering whaling purely as a commercial harvest to concern over the psychological impact of noise on marine mammals. It seems that neither the public nor scientists have yet been able to adjust to this rapidly changing landscape. Scientists deal mostly in facts, and the ATOC project looked only at the facts as they saw them. Perhaps a group practiced in the skills of public relations would have told them that the public reacts to a mixture of fact and emotion, the balance often shifting towards the latter.

Then there are the defense conspiracy theories. Ocean acousticians are accustomed to working with defense agencies, indeed military support was virtually the only available source of support in the early days of this research. They have inured themselves to the necessity of confronting the issues of technological advantage in war, and have made their individual peace with the contributions that they make. They also know that much of the work performed with defense funds is unclassified, has no application to war, and that an association with a defense agency should not automatically brand an enterprise with an evil stamp. If some of the people who see a “Dark Force” in ARPA, formerly DARPA (Defense Advanced Research Projects Agency), actually met and became acquainted with both the people who work there and the internal organisation, they would almost certainly be surprised at the rather ordinary and human side. No fear rivals that of the unknown.

The lessons of this debate have application far beyond the future conduct of the ATOC project. We are only beginning to learn to manage ocean resources. The issue of acoustic pollution in the ocean will arise again and again. Perhaps the next major project to face the battlefield will be the proposed development of supersonic air transports. These transports will generate a shock wave that will penetrate the ocean and cause considerable noise pollution in the near-surface layers, invoking just the type of issues that ATOC now faces, if not worse.

### *Recent events from the front*

Latterly, there have been many articles in science magazines and newspapers, including the New York Times and another front-page article in the L.A. Times by Paddock on 5 May entitled “Beneath the not-so-silent sea”. The more recent publications have purged themselves of the temptation to hark on tales of mass destruction, and are addressing the wider issues of noise pollution in the ocean in a more balanced fashion, as seen by the decay of ‘negative’ articles in Fig. 2. Nevertheless, the issues have yet to dawn on many people’s consciousness. The most recent L.A. Times article quotes a spokesman for the shipping industry, who was clearly incredulous that something as absurd as noise pollution could be a problem saying “What do they want, no ships in the ocean?... We have water pollution, air pollution-the latest thing was our ballast water. Noise pollution? That’s a whole new one.” If the ocean noise pollution debate continues to mature at the current rate and maintains the current level of interest, the commercial fleet would be well advised to heed this wake-up call and learn from ATOC’s mistakes instead of taking acquiescence for granted.

While the ATOC debate has been raging, several researchers have been working with Congress to make provisions for research activities in the re authorization of the MMPA. As they pointed out, it is a fundamentally flawed process that permits a fisherman to kill a member of an endangered species more easily than for a scientific

researcher to study it. As a result of this effort, the law has now been significantly amended to make it appreciably easier for many researchers to operate. The revised MMPA passed both the House and Senate on Wednesday 27 April and awaits only the President's signature. There are three areas of change; Firstly, the category of acceptable research has been broadened from that which must directly assist in conservation to any bona fide research that contributes to knowledge of marine mammals. Secondly, "harassment" has been defined and categorized into two classes, that which has the potential to injure and that which has only the potential to disturb. Research that falls under the second category would be exempt from the act by a general authorization. The third change is that the act provides for the rapid issuance of a permit (even before the public comment period has expired) if delay would likely result in injury to an animal or loss of significant research opportunities. These changes will take effect in 120 days or less after enactment. While the ATOC project might not qualify under the second category of harassment, the clear intent of Congress is to treat scientific researchers as an asset rather than a liability in their efforts to further knowledge of marine mammals.

### *Conclusions*

The ATOC debate has evolved rapidly and is now remarkably mature considering the short time period for which many participants have been aware of the issues. The initial misunderstandings produced an explosion of ill-founded protest facilitated by a combination of poor preparation by ATOC, limited available time for response and an overly eager opposition. This protest has now mutated into a thorough discussion of a number of interesting and valid issues, although many people on the periphery are still operating on a very emotional platform. The initial explosion was made possible by the ATOC public relations naiveté and the timing of the Los Angeles Times article, which was widely syndicated. With modern rapid and voluminous access to information by the public, we must expect an increased level of challenge to authority and established process. The NMFS public hearings have set a precedent, it is the first time a public hearing has been granted for an MMPA permit application. These challenges may often be misguided at the outset, an inevitable result of the complexity of modern issues and the limited resources and ability of the public to assimilate new information in the time available. The ATOC debate has demonstrated that elected representatives will respond directly to public pressure, and perhaps without waiting for a full assessment of the situation. There are therefore precious few checks and balances to prevent precipitous action on the part of US governmental bodies, made clear by the involvement of the House of Representatives, the Senate and the Office of the Vice President, ultimately on the basis of a postdoctoral interview to a newspaper. The situation is made significantly more volatile by the ability to rapidly disseminate information over electronic networks and via fax. The combination of increasing environmental responsibility, disenchantment over scientific and governmental integrity, and the widely accessible information highway combined to produce an explosive mixture which government, the public and scientists need to learn how to handle more responsibly in the future.

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