Whales Competing with Humans?[1]

by

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This paper is an updated version of a document with the same title, dated 1 August 2006, to be found on the web-sites of the Whale and Dolphin Conservation Society (WDCS), the WorldWide Fund for Nature (WWF), the Global Ocean charity and the International Fund for Animal Welfare (IFAW). A longer and more technical version may be consulted at the same locations, entitled, simply, "Whales Competing?" This revision of the less technical paper has been made as a Background Document for the **Symposium on the State of the Conservation of Whales in the 21st Century**, being convened in New York, April 12 & 13, 2007, by The Varda Group for The Pew Charitable trusts. <http://www.vardagroup.org/whalesymposium>

The significant change is the addition of an analysis of the implications of commercial whaling by Japanese vessels in the Indian and tropical Pacific Oceans in the late 1970s, under Spècial Permits for scientific purposes as authorized by Article VIII of the International Convention for the Regulation of Whaling 1946. This analysis is summarized in the new **Annex**. The extensive data on the stomach contents of the hundreds of Bryde's whales killed in those "experiments" was ignored by authors S. Ohsumi and T. Tamura in their papers on food consumption of whales a critique of which is the main subject of this paper. They ignored Ohsumi's own data from ocean areas widely spaced in the Southern hemisphere, which showed that Bryde's whales there eat virtually no fish, and they used instead a limited sample, studied by P. Best, of whales caught in coastal waters off South Africa, some of which were eating fishes, but which that author had himself recognized to be atypical; he even went so far as to suggest that there might be two forms of Bryde's whale, one living in South Africa's Indian Ocean coastal waters, the other being widespread and oceanic. **The result of the Tamura & Ohsumi decision not to use the data from the scientific whaling operations was a 15-fold inflation of the fish consumption by Bryde's whales and a 13-fold inflation of the estimates of total fish consumption in the Southern hemisphere by all baleen whales.**

In fact none of the data obtained then or more recently from "scientific whaling" have been used in the Ohsumi & Tamura studies. It has been pointed out again and again by scientists and authorities that do not approve of commercial-scale "scientific whaling" that most necessary data can be obtained as well or better by non-lethal methods. But qualitative and quantitative information about the diets of whales is much more difficult to obtain non-lethally, so the scientific whaling operations might appear to have some justification in that respect.That argument has indeed been used in practically all of the materials published and distributed by the proponents of such whaling. Thus the failure to use those data would appear surprising, until it is realized that they simply do not support the idea that the baleen whales, especially the Bryde's whale, are big consumers of fish and therefore might be significantly competitive with humans for marine resources, and so such data are inconvenient to those who seek to promote that idea.

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Interpretations and views expressed are solely those of the author.

Whales Competing with Humans?

Sidney Holt
Paciano, 24 February 2007

"Truth is complicated, but a lie is streamlined. All the credibility of the lie is there because the uncomfortable dangly bits are tucked away in the weave of plausibility. Nice smooth lies are easily swallowed. A lie will also fit in with our expectations. We like to construct a picture of the world as simple as a pantomime plot"

Richard Robinson, 2005

ABSTRACT

According to the Government of Japan ***whales eat from 300 to 450 million tonnes of fish*** each year, and that claim is set against the facts that ***800 million humans are undernourished*** and that the ***annual catch from the sea by humans is only 85 million tonnes***. [Press statement by Minister Tsutomu Takebe, 17 June 2006] This claim is reflected in a so-called **Declaration** that received a majority of just one vote in the closing session of the International Whaling Commission meeting held on the following day. That document claimed that:

scientific research has shown that whales consume huge quantities of fish making the issue a matter of food security for coastal nations… .

These statements derive from documents distributed by Japan's Institute for Cetacean Research (ICR) but do not reflect any serious scientific opinion. Those documents purport to show that all cetaceans - that is, the Great Whales, and the smaller whales, dolphins and porpoises – annually consume between 250 **and 430 million tonnes of "marine resources"** and that between **63 and 74 million tonnes** of that quantity are fishes, of which about 20% are consumed by the baleen whales which are the subjects of IWC regulations and decisions. Fish l**andings** (which are very much less than actual **catches**, much of which are discarded at sea or otherwise wasted) **were actually 75 million tonnes** in 1996 – the base year for the ICR study - and have not changed very much since then.

The ICR study employed seriously flawed methodology, contained many errors (almost all in the same direction) and used the limited published data selectively, resulting in a serious upward bias in the quantities calculated. **Here, the figure for fish consumption by whales, using more correctly the information available to ICR, is revised to 5-7 million tonnes or less.**
[But see the Annex for an indication of how big the selective bias actually is.]

This, like the ICR figures, has little direct relevance to the question of whether and by how much, if at all, whales might affect fisheries and *vice versa*, but it does provide another perspective to the arguments on this matter. That question might only be answered eventually by using different methods correctly, and other data less selectively.

The rationale, political strategy and tactics behind the fallacious Japanese claims are here exposed.

Whales Competing with Humans?

A critique of the spurious claim by the Government of Japan that whales eat several times the weight of sea fish than are caught by humans, and that this diminishes human food security, threatens fisheries, and even hinders the recovery of depleted populations of the largest whales.

Sidney Holt*

Paciano, 10 March 2007

A lie can be half way around the world before the truth has got its boots on.

Mark Twain

An explanation

This document does not pretend to be a deep or comprehensive critique of current arguments about the interactions of whales and other marine mammals with fisheries, and the possible deleterious consequences of those interactions from the human point of view. At the scientific level that is a matter of complex modeling of marine ecosystems and the application of good and varied data to the models. There is, I think, a broad consensus among scientists that we are still very far from being able to do those things in such a way as to contribute to responsible fisheries management. Here, I simply examine the apparently "common sense" idea that to the extent that marine mammals eat fish we would be better off if we kept them in check or perhaps eliminated them. This simplistic, naïve, misguided but to some people persuasive notion is currently being promulgated extremely actively – and expensively - by a few governments and bureaucracies for various purposes that have little to do with fisheries management.

Our immediate concern here is the claim by Ministers, Diet members and others connected with the Government of Japan, based on documents produced by the Institute for Cetacean Research (ICR) in Tokyo, that **whales eat between 300 and 450 tonnes of fish per year**, that this is many times the global catch of fish by humans and that this constitutes a threat to world fisheries and to future food security. Here, and in my longer, more technical supporting critique (referred to here as the *Primary* document) I show that the data and cited methods used – or, rather, misused - by the ICR scientists concerned, properly interpreted, lead to the conclusion that those whales that are subject to, and affected by, the moratorium on commercial whaling adopted by the IWC in 1982 (namely, some of the populations of some species of baleen whales), annually consume **7m tonnes of fish, or less**. This is less than 10% of human landings of fishes, squids and cuttlefishes, and shrimps and prawns, and a significant proportion of that quantitiy is of species not consumed by humans and in some case that are ecologically competitive with the human-preferred species. . In addition, the quantities killed but not landed (incidental and discarded catches, organisms of no commercial value) are of the same order of magnitude as the landings, and the landings themselves contribute less to human nutrition than is commonly thought.

It is for the reader to conclude whether the misleading statements quoted, and the accompanying propaganda sheets, arise from scientific carelessness or incompetence, or from deliberate dishonesty, or perhaps both. But in the face of these conclusions, my deeper aim is to expose and deplore junk science and its promulgation and use for political purposes. I deplore it in this context because it, and the scientists involved in it,

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bring marine ecology and fisheries science into disrepute, and in doing so weaken respect by the general public for science itself. Although I point here to scientists at the ICR, some others share the blame for the present sad situation of the International Whaling Commission. Its Scientific Committee has not - as a collectivity – in recent years years, seriously challenged the barrage of nonsense coming from that institute.[1] But the Commission's Secretariat is, I think, also culpable in not yet having published the papers contributed to, and the full report of, the scientific meeting it convened in San Diego several years ago to examine the "whales competing with humans" issue, nor the volume of basic documents that define, describe and justify its own Revised Management Procedure – now more than a decade in arrears.

1. Introduction

Mr. Tsutomu Takebe, Agriculture Minister in the Government of Japan, recently told journalists: ***You may not know but whales eat more than three to five times the amount of maritime resources than humans do*. *That comes to 300m to 450m tons of fish. On earth there are 800 million people who are undernourished.***[2]

The two lies in that statement, and the false implication that in a planet without whales in its ocean there would be fewer undernourished humans, have been around the world many, many times and are still circling. Few serious marine scientists have investigated and challenged them; most of them think it would be a waste of their time to counter such nonsense. Politicians and bureaucrats in many countries have parroted them unquestioningly and, unfortunately, they have been repeated in the global media *ad nauseam*.[3]

To make matters worse – and more shamefully – the International Whaling Commission (IWC) adopted – though only by one vote - on 18 June 2006, at it's meeting in St Kitts and Nevis, a so-called **Declaration** in the form of a resolution containing the following paragraph:

ACCEPTING that scientific research has shown that whales consume huge quantities of fish making the issue a matter of food security for coastal nations and requiring that the issue of management of whale stocks must be considered in a broader context of ecosystem management since ecosystem management has now become an international standard.[4]

That resolution was based on no new data or analyses. It was co-sponsored by, among others, the Governments of the present whaling countries: Japan, Norway and Iceland; Denmark cast the decisive vote in favour. It was linked with other statements in the Declaration to the effect that the moratorium decision had not had the benefit of scientific advice (untrue!)[5], that it was originally not intended to be permanent (half-truth) and was no longer necessary if it ever had been (questionable).[6]

The *economies with the truth* that all these words convey derive from "junk science" sponsored by the Government of Japan and conducted by the Institute for Cetacean research (ICR) in Tokyo. They have been promulgated for the triple purpose of (i) inducing governments of small Third World counties to join the International Whaling Commission (IWC) and – sweetened with large wads of "development aid" money - to vote with Japan for a series of actions aimed at dismantling the conservation measures the IWC has adopted over the past three decades; (ii) to provide an apparently rational justification for the continued expansion and diversification of Japan's commercial whaling, conducted under Special Permits for so-called scientific research, outside all international regulations and norms; (iii) to open the way to future ***un****sustainable* exploitation of whales, which is necessary for continued profitability, especially if the Japanese Government's indirect subsidy to the industry were to be reduced or even eventually discontinued. Behind these specific purposes lies a strategy eventually to lift the current general moratorium on commercial whaling, without corresponding safeguards for the remaining whale stocks, to gut the precautionary measures the IWC has agreed to apply should commercial whaling ever be re-authorised, to abolish the sanctuaries for whales in the Indian and Southern Oceans where commercial whaling has been indefinitely stopped by the IWC, and to prevent the establishment of further sanctuaries as is desired by most coastal states in the Southern Hemisphere.[7]

The absurd Japanese claim that whaling will significantly improve Global Food Security has been made especially in United Nations fora such as the Food and Agriculture Organisation (FAO) where it has generally been politely heard, duly recorded and diplomatically ignored. Meanwhile, Japanese authorities remain deaf to the proposition that if the depleted whale stocks were allowed to recover from past over-exploitation they could perhaps eventually provide a useful supplementary food resource for future human generations, in certain regions, **if** those generations were interested in that and were sufficiently hungry – but to that end those stocks would need a recovery priod of at least half a century.

The myths Minister Takebe relayed to journalists, which have been published in numerous propaganda sheets issued by the ICR, the Japan Whaling Association and the Fisheries Agency – a branch of the Government of Japan – come from documents written by two scientists at ICR – Drs S. Ohsumi and T. Tamura - that were unveiled to public gaze in 1999, 2000, 2001 and by publication in 2003. Although the first two were circulated to the Scientific Committee of the IWC they have never been peer-reviewed nor published in the scientific literature. A modified version of the 2000 document by Dr Tamura was, however, – though also not refereed - published in 2003 by FAO.[8] Those documents applied flawed methodology, used the limited available data selectively and drew unwarranted conclusions from those data. Unfortunately, the publication of Tamura's version by a respected United Nations Agency has given this material an appearance of authenticity it does not deserve.

The great Florentine philosopher and political advisor, Nicolò Machiavelli, wrote

Men are apt to deceive themselves in big things,
but they rarely do so in particulars.

The subject of this study - the possible effects of whales on fisheries - is hardly a "big thing", except perhaps to those with a remarkably narrow view of our world's current problems. It is, I think, one of the rare "particulars". Although few people are now aware of how extremely valuable in financial and nutritional

terms were the baleen whales of the Southern hemisphere when, in the 1930s and early 1950s the (unsustainable) production from them constituted more than 15% of the global biomass landings and value from the oceans. Nicolò also wrote
All men can be led to believe the lie they want to believe.

During 2004-2006 I undertook an exhaustive critical review of Ohsumi's & Tamura's work, published under the title ***Whales Competing?*** In doing that I also examined all the sources of both data and methodology used by Tamura & Ohsumi, as well as some of the relevant published data they did **not** use**.** My review is in the public domain in several languages (French and Spanish as well as the original English, and an Executive Summary in Japanese) on the web-sites of several non-governmental organisations (NGOs): Whale and Dolphin Conservation Society (WDCS), Worldwide Fund for Nature (WWF), Global Ocean, Humane Society of the US (HSUS), International Fund for Animal Welfare (IFAW), and Global Ocean charity It has been made available in hard copy to a variety of government agencies, associates and persons, mostly scientists and administrators and some politicians.

I have written the present document to meet requests by recipients of the original (***Primary)*** document for something shorter and less technical. In it I refer at the core to the results given by Tamura in his version published by FAO, whereas I had based my original analysis mainly on the Tamura & Ohsumi documents of 1999 and 2000. There are several differences among those documents, and some of them are important in relation to specific arguments, but most of those differences are little consequence to the main thrust of the ICR and the Government of Japan.

Scientists are aware that the question of whether whales or cetaceans eat more or less of marine living resources, including some fishes, is practically irrelevant to the determination of the manner and degree to which cetaceans may be influencing fisheries, and vice versa, Demonstrating **competition** involves much more than noting some dietary overlaps, and even if these are properly documented there remains a long and difficult series of research steps to determine whether one activity is affecting the other, or will in future affect the other in any important way. In the ***Primary*** document I have given some leads to this problem, and have also shown that a very small fraction of the marine life killed by humans actually enters human bodies. I shall not repeat those analyses here. But the cautious conclusions of the IWC sponsored scientific workshop on the subject, held in La Jolla, California, in June 2002, **are** worth recalling:

There is currently no system for which we have suitable data or modeling approaches to be able to provide reliable quantitative management advice on the impact of cetaceans on fisheries or of fisheries on cetaceans.[9]

2. Inside and under Minister Takebe's statement

Truth is complicated, but a lie is streamlined. All the credibility of the lie is there because the uncomfortable dangly bits are tucked away in the weave of plausibility. Nice smooth lies are easily swallowed. A lie will also fit in with our expectations. We like to construct a picture of the world as simple as a pantomime plot.[10]

The current global annual landings, from the sea, of fishes and shellfishes – shelled molluscs such as mussels and oysters, squids and octopi (cephalopods), and crustaceans such as shrimps, crabs and lobsters – total about 85 million tonnes (calculated as a notional "wet weight").[11] This quantity, of what FAO calls "Capture production" – that is, excluding marine aquaculture - has not been changing much in recent years. The figures that according to Minister Tabeki are "three to five times" this are a series of alternative values provided by Tamura & Ohsumi for the total consumption of food by all species of marine cetaceans, that is large whales, small ones and marine dolphins and porpoises. Those figures were, by three different methods, 249, 270 and 434 million tonnes.[12]

Most of the food consumed by cetaceans is not, however, **fish.** The corresponding three figures for fish consumption given by Tamura are 63, 57 and 78m tonnes, which is between 18% and 25% of the total.[13] To the rest of the cetaceans' diets the molluscs (practically all squids) contribute between 28% and 37%, while the crustaceans contribute between 43% and 54% By contrast 85% of the human catches (i.e. 72m tonnes) are fishes; the molluscs contribute 8% and the crustaceans 7%. Just less than half the molluscs are squids and cuttlefishes, the rest are externally shelled – mussels, abalones, oysters and the like. Of the crustaceans just over half are "shrimps and prawns" (including a tiny quantity of Antarctic euphausids – krill), the rest are from groups of larger, bottom-living species. By contrast virtually *all* of the presumed consumption of crustaceans by "whales" consists of tiny animals such as krill, copepods and amphipods.

Minister Takebe accused "whales" of doing all this consuming of marine (living) resources. In fact the ICR figures are for all the large whales, medium sized cetaceans commonly called "whales" (such as the so-called killer whale/orca, the several species of pilot whales, the narwhal, the beluga/white whale, bottlenose whales), and also all the many species of much smaller dolphins and porpoises that are normally not called "whales" in any language. There are two good reasons for our concentrating here on the "real" whales with which people are familiar, such as the blue whale, the fin and humpback whales and other species of baleen ("whalebone") whales as well as the great toothed sperm whale ("Moby Dick", or cachelot). The first reason is that the calculations of food consumption depend, among other things, on knowledge of how many of them there are alive right now. Although there is still a good deal of uncertainty about this, the sizes of populations of the baleen whales and of the sperm whale have been studied rather intensively for some years, but the numbers of the dozens of species of smaller cetaceans are not at all well-known (except in some cases of those that are naturally rare or nearly extinct and have therefore attracted scrutiny by biologists) and have not been the subjects of so much research in the wild. Furthermore we have very little *quantitative* knowledge about the dietary compositions of most species. Most of Tamura and Ohsumi's calculations of prey consumption by the smaller species, especially those that are not at present targets of commercial operations, use **assumptions** as to the compositions of their diets and **guesses** as to their numbers.

The second reason for our concentrating here on the baleen whales and the sperm whale is that it is only those, along with the orca and the North Atlantic bottlenose whale[14], that have been subject to IWC regulations and conservation measures and whose futures may therefore be affected by the general commercial moratorium and by the declarations of whale sanctuaries.[15] It may be noted here that the sperm whale is not excluded from the moratorium but is in any case fully protected by another specific and unconditional – and on the face of it permanent - moratorium adopted in 1981.

Let us then look at what Tamura & Ohsumi have to say about these large whales. First, the sperm whale. At this point I note that from now on, for reasons that will become clear, I refer mainly to Tamura's & Ohsumi's results, as given by Tamura, using their Method 2, which is the only one of their three methods that might be methodologically valid, and therefore credible in principle, though it is not so in their particular application of it.

Tamura concluded that half a million sperm whales, world-wide, having a total biomass of **11.5m** tonnes (so with an average individual weight of **23** tonnes), consume **76m** tonnes of marine resources annually.[16] Of that amount 25% was **assumed** to consist of fishes (**19m** tonnes), 70% of squids (**53m** tonnes) and 5% small pelagic crustaceans such as krill (**4m** tonnes).[17] For comparison the global annual landings of squids amount to about **3m** tonnes. Those figures might signify some competition with humans but the squids in the whales' diet are nearly all of different species from those caught by humans.

Before considering the baleen whales, that are currently of more interest to us[18] I cast a brief look at one of the two other "IWC" whales – the **orca** or **killer whale**, which is, like the sperm whale, a toothed species. According to Tamura, about 70,000 orcas (80% of them living in the Southern Hemisphere – mostly in the Southern Ocean.)[19] with average body weight of 2 tonnes, consume **1.1m** tonnes of prey annually. Of that 83% was **assumed** to be fish (**0.9m** tonnes), the rest cephalopods; no pelagic crustaceans, of course. Little credence is to be given to these figures. Apart from great uncertainties about their numbers, orcas are known also to consume, for example, seabirds and other marine mammals, including seals and even young of the "great" whales. I shall have little more to say about them here. I note, in passing, that they were, like the sperm whale and the North Atlantic bottlenose whale, unconditionally "protected" by the IWC before the general moratorium decision of 1982.

As to the North Atlantic bottlenose Tamura & Ohsumi calculated that 44,300 of them, thought to be living in the Central North Atlantic near Iceland, with an average body weight of 1.7 tonnes, and **assuming** their diet consists of 15% fishes, 70% squids and 15% planktonic crustaceans, consume annually 0.13m tonnes of fishes, 0.60m tonnes of squids and 0.13m tonnes of crustaceans. I have not considered this species further here because the figures used are, essentially, guesses or, at best, guestimates.[20]

Tamura's figure for the consumption of prey by the **baleen whales** is **140m** tonnes, of which **10**% (**14.5m** tonnes) is fish and the rest planktonic crustaceans.[21] Of this total prey nearly half (**43**%) is said to be consumed by **minke** whales (**60.6m** tonnes); **35**% (**49m** tonnes) by **fin** whales; **11**% (**16m** tonnes) by **Bryde's** whales in the Southern Hemisphere and North Pacific; **4**% (**5.5m** tonnes) by **humpbacks**. The remaining **7%,** totaling nearly **10m** tonnes is said to be consumed by **blue**, **pygmy blue, sei**, **grey** and **right** whales.[22]

The division of the total **14.5m** tonnes of **fish** by species is not in the same proportion as the total prey figures. Minke whales are presumed to be like the baleen whales lumped together, with a diet including **10**% fish. But neither of the blue whales' diets includes fish, and fish comprise less than **2**% of the fin whale diet. However, **38**% of the Bryde's whale diet is said to be fish, and **26**% of the humpbacks**. (But see the Annex for an account of the gross exaggeration involved in the Bryde's whale figure.)** Those proportions lead to the following estimates of fish consumption by the various species of baleen whales as:
minke – **6.3m** tonnes; Bryde's – **6.0m** tonnes; humpback – **1.4m** tonnes; fin – **0.8m** tonnes: sei[23] and others – less than **0.1m** tonnes.[24]

This, then, is the internal message of the ICR calculations, though these numbers are not obvious in Tamura & Ohsumi's tables. The "IWC whales" – that is those regarding which the IWC has accepted the responsibility to take management actions, including the moratoria and the sanctuaries[25] - sperm, orca, N. Atlantic bottlenose, and the baleen whales – consume, by these sorts of calculations, a total of about **34m** tonnes of fish annually. Of the **85m** tonnes landed by the marine capture fisheries[26] **5m** tonnes were crustaceans (6% by weight, and of those more than one half were shrimps and prawns); between **3** and **4m** tonnes[27] were squids and cuttlefishes (about 5%); and about **75m** tonnes were fish (90%). So, the "official" outcome of the Japanese Government's long effort to prove that whales threaten fisheries is that they consume less than half as much fish (**45**%) as are caught annually by humans. If now we are generous and put all the cephalopods together with the fishes we find that just under **39-40m** tonnes of fishes and cephalopods were being consumed annually by the "IWC whales" as against landings by humans of **78-79m** tonnes – just one half.

Let us now examine the ICR calculations more closely.

3. Methods

Tamura & Ohsumi used three methods to estimate prey consumption, all of which depend on (i) estimates of the numbers of animals of each species, in each of their three Regions (ii) figures for the average body weights of each species, and (iii) a procedure to determine the daily (and so annual) food consumption per animal, which is dependent on its body weight and, in the case of their Method 2, on the types of prey consumed. They applied the same sets of figures for (i) and (ii) in their calculations for each method. They calculated annual consumption by multiplying the estimate of daily consumption by 365, although most of the baleen whales feed for only part of the year – roughly one third of the time. [28]

In their **Method 3** it is assumed that *per capita* food consumption is directly proportional to body weight; that is if one whale is twice the size of another it will consume twice as much, and so on. Such an assumption is quite contrary to all modern studies of the scaling of metabolism and/or food consumption to an animal's body size. It leads Tamura and Ohsumi grossly to over-estimate the food consumption of the large whales. Their results obtained by using it can be discarded at the outset.

Their **Method 1** derives from a paper by Dr. David Sergeant published in 1969, in which he compiled figures for the quantities of dead fish consumed by some dolphins and small toothed whales held in aquaria. There has been much debate among scientists about that study, some of it published. Some of Sergeant's data were merely hearsay (and of course he did not conceal that). Many question the applicability of such captive feeding observations to the feeding of free-ranging wild animals; there are some arguments that the captives eat more than equivalent wild animals, and other arguments that they eat less. But the more important question here concerns **the extrapolation of those observations to animals weighing up to more than 200-times the median weights of the captives**, and, further, to animals that eat planktonic crustaceans and not very much fish, dead or alive.

Sergeant fitted what is called a **power function**[29] to his data, and Tamura & Ohsumi used a modification of that (but still based on Sergeant's data), published by S. Innes and three co-authors in 1986, to make the extrapolations. It should be said that Innes *et al* did not produce their modification for the purpose of improving any extrapolation, but rather to demonstrate that Sergeant had not calculated the power function correctly; they obtained a revised power exponent estimate of 0.67. (I re-analyzed Sergeant's data and showed that for the kinds of calculations made here they are compatible with an exponent value of 0.75; see below). This explains in part why Tamura & Ohsumi's consumption estimates by their Method 1, for the larger cetacean species, are lower than those they obtained by Method 3.[30] In any case, an extrapolation of more than 200-fold beyond the range of the data, and, furthermore, applied to animals with completely different kinds of diets and feeding behaviours, is, scientifically unacceptable.

We are left, then, with Tamura & Ohsumi's Method 2. This involves the use of a power function to estimate the daily metabolic (energy) needs of a whale as a function of its weight, then the calculation of what weights of various kinds of foods would satisfy those needs, and finally the multiplication of those values by 365 and by the numbers of whales. There are practical problems at each stage of this procedure, and some are real pitfalls, as we shall see.

The power function used by Tamura has an exponent of 0.78. Use of this value tends to exaggerate the increase in energy needs with body size, as compared with the general consensus that an appropriate value is 0.75, but the consequences to Tamura's calculations are not large. Tamura attributes the function he uses to the Icelandic scientists J. Sigurjónsson & G. A. Vikingsson: however, *they* took it from a study by D. Lavigne, but - without explanation - changed Lavigne's exponent from 0.75 to 0.78 This might not have mattered much except that they did not correspondingly adjust the value of the multiplying constant Lavigne had estimated. This had the effect of inflating S & V's figures for food consumption and, consequently, also those obtained by Tamura.[31]

There are some other problems with the value of the constant (multiplier). In earlier papers C. Lockyer had tried to relate **basal** and **resting** metabolism to other metabolic quantities, taking account of the activity and growth of the whale; she decided to augment the basal figures by adding what she thought were appropriate amounts or by multiplying them by an "activity factor". S & V, in determining the value of the constant they would use, apparently misunderstood Lockyer's upward "adjustments" and doubled up the activity correction. They also assumed that assimilation of food is only 80% efficient in baleen whales and accordingly inflated their food intake estimates by a further 25% "correction". Tamura & Ohsumi took over this "correction" too.

The reason for the efficiency factor is not easy to track down – it has been used by other authors – but in fact it comes from an assumption that baleen whales cannot digest chitin, the stuff from which the shells (carapaces) of crustaceans are made. But Norwegian scientists have shown conclusively that that is not true. The stomach of the minke whale, and of other baleen whales also, is many chambered, rather like that of ruminant terrestrial mammals. The first chamber contains bacteria, of species unique to these whales, whose function is to break down chitin, just as the bacteria in the first stomach chamber of a cow break down otherwise indigestible cellulose in its plant diet. Thus the food consumption estimates for the majority crustacean part of the baleen whale diet are all 25% too high just for that reason. But, worse than that, this efficiency factor is applied to **all** food items.

It is not easy to find by how much this sequence of upward adjustments inflates Tamura's results, but it seems to be by at least 50%.

The next stage in the application of Method 2 is to determine from the estimate of energy needs the quantity of food that would satisfy them. This involves a quantity called the **energy density**, i.e. the energy (caloric) content of a unit weight of each particular type of dietary item. There are many published data about this for many marine organisms, and Tamura & Ohsumi selected some of them to suit their purposes. Published energy density figures are highly variable and can differ widely even between closely related species. Tamura & Ohsumi merely took values for some unspecified "fishes" and "invertebrates". But even the applications of their selection are muddled. For example they chose a value, say, between that for planktonic crustaceans and that for fishes, and then applied the intermediate value to the entire diet regardless of the actual composition of the diet. This gives biased estimates of food consumption. The correct procedure is first to determine the species composition of the diet and then apply the appropriate energy density value to each component.

S & V had used energy density values of 0.93 kcals/g for crustaceans and 1.3 kcals/g for fish and cephalopods (Some published estimates give very different values for these two different types of prey animals.). Tamura & Ohsumi however adopted a value of 1.3 kcals/ for baleen whales in the Northern Hemisphere (as well as for toothed whales everywhere) as if they were eating only fish, and 1.11 kcals/g for baleen whales in the Southern Hemisphere, assumed to be eating almost only crustaceans, except for the Bryde's whales.[32] Thus their method took no account of the observed compositions of the diets. S & V, and Tamura & Ohsumi, cite the same source for the 1.3 figure (Stemle & Terranova, 1985) but they and several other researchers who have reviewed the literature on this subject have shown that the energy density can vary over at least a three- or four-fold range even among fishes. And the values depend critically on the condition of the prey, especially lipid and water content, which vary seasonally and in other ways. The energy density indices of different crustaceans eaten by baleen whales also varies enormously from species to specie; some amphipods have an energy density two to three times that of Antarctic krill, and copepods are different again. The conversion from energy needs to biomass ingested to meet those needs is a complex matter, but the approach to it taken by Tamura & Ohsumis is possibly the least reliable that can be imagined.

4. The sizes of whales

The next question concerns the meaning and accuracy of the values taken by Ohsumi and Tamura for the average weights of whales in a species population. These have two components: *the range of sizes among individuals* of a species (depending principally on their ages, but also on their sex and their "condition", commonly defined as the actual weight divided by the cube of the body length), and *the average size in a population* consisting of animals of a wide range of age, of biological states and of two sexes (female baleen whales – unusually among mammals – are bigger than males, while male toothed whales, especially sperm whales, are substantially bigger than the females).

Whales cannot be weighed whole. In the 1970s Dr Christine Lockyer compiled data from studies in which dead whales on factory ships or landed at shore stations had been chopped up and the parts weighed and the results added together. She also looked at the relation between those weights and the measured lengths of the animals – length is one of the observations of all killed whales that is required by the IWC, others are sex and, if female, reproductive state. Lockyer drew graphs of body weight against length and fitted power functions to the results. The exponent is, as expected, close to 3, the cube, but not exactly that, and her results varied among species, and also between sexes and with the age of the animal as judged mainly from its size – she was working at a time when the ages of few animals had been determined from their anatomy, with unclear results. There is however a snag with respect to the constant (multiplier) of the cubic or, more generally, power equation. The great whales, especially the baleens, change considerably in weight during their annual feeding and migration cycle, as fat is accumulated or used, and especially by the pregnant and lactating females. Tamura & Ohsumi, as well as the Icelandic scientists and others, relied heavily on Lockyer's calculations; these were carefully done but would not meet current standards of mathematical/statistical analysis.[33]

Lockyer's studies, being conducted on whales killed in the restricted whaling season, reflect their fatness and other qualities at those times. The changes during the year were well known to whalers who, as far as was practicable, timed their operations to get high oil yields, as well as to catch the largest whales they saw, there being minimum size limits for each species (except for the minke) set by the IWC. In fact scientists knew at the time that the whalers and national inspectors on their ships and platforms commonly used what we called "elastic measuring tapes"! Thus the average reported measurements were longer than the actual lengths, and those were certainly considerably longer than the average lengths of whales in the living populations. An additional element of size selectivity in Antarctic pelagic whaling, particularly, is that migrating whales at the beginning of summer do not all arrive at the summer feeding grounds at the same time; males and females, younger and older, have different schedules, and whaling was timed to take advantage of those differences.

Even now there are not published power functions relating length to weight for all species. Data for minke whales were sparse in the early days because exploitation of them began late in most regions, especially the Southern Hemisphere. That has now been corrected, minke whales being somewhat easier to weigh than the blue and fin whales ten to twenty times their size. Rough and ready comparisons between similar species have been made to fill the remaining gaps, but this still leaves uncertainties about average weights through the entire year in comparison with the weights during whaling seasons, that are mostly, though not always, on feeding grounds (minke whaling from Brazil, unusually, took place in the breeding areas), and in other cases whaling was concentrated on migration routes, which in one direction would give high values and in the other direction low ones[34].

The second component of this process – calculation of the average size of animals in the living population – is even more problematic. Clearly, the age and sex compositions of historical catches are not representative – in any case they mostly exclude juveniles – and they also have greatly changed over time because of unsustainable exploitation, which of course leads to continuously declining average age and hence size. For some of their results Tamura & Ohsumi used the reported average lengths in catch data and they applied curves given by Lockyer and others for growth in weight against age, where ages were known from examination of the waxy plugs in the ears of baleen whales (that have rings as in tree trunks), and corresponding studies of the teeth in sperm whales and the smaller toothed species, to obtain weights. In many cases data for this procedure do not exist, and then the ICR authors fell back on a procedure proposed by

E. W.Trites, and D. Pauly in 1998. That procedure, which is intended to provide an estimate of the average size of animals in an entire population (not merely the exploited part of it) is – as I show in the *Primary* document – of dubious validity, especially for Tamura & Ohsumi's purpose. Their method is complicated but rests on the assumption that the age compositions of whale populations are similar to that of the human population in the USA at the turn of the 20th Century,[35] together with a figure for the longest individual ever recorded of each species, and another for the maximum life-span of the species. For the Balaenopterids the life-spans were taken from a 1979 paper by Ohsumi, but those spans were practically arbitrarily chosen by its author; in no species have the ages of very old individuals been reliably determined by recognised methods, such as rings in earplugs and teeth.[36]

Estimates of food consumption are roughly proportional to the average body weight to a power less than one. With a power exponent of 0.78 as used by Tamura & Ohsumi, or even a more appropriate value of 0.75, the estimates of consumption are critically dependent on the values of body weight used, especially when extrapolations - far beyond recorded data and comparative studies - are being made to the metabolism of very large animals such as the great baleen whales and the sperm whale. So the choices made of various options for average sizes are important.

Tomaua & Ohsumi used different sets of average weights in their 1999 and 2000 documents.[37] In the 1999 document a weight in given for each whale species in the southern hemisphere, and a – usually – smaller one for the North Pacific and the North Atlantic, though these two latter are always identical to the third decimal place, meaning they came from the same data sets, if any. In general, these differences are in accord with published studies of commercial and scientific catches (in which at least body lengths are measured) and research on growth rates. But for the 2000 paper most of these had been changed, nearly all were larger (the humpback and the sei in the Northern Hemisphere were the only exceptions)[38] and for each species the average weight is now the same in all Regions.

The changes were not trivial. For each baleen species they would (other things being equal, of course) increase the estimates of food consumption by 20-25%. In some but not all cases these changes can be traced to the discarding of observational data and adoption of the theoretical method introduced by Trites & Pauly, using a global figure for each of them, despite the known differences in growth rates in different regions. Furthermore, the average age of whales in a population depends, of course, on its exploitation history so the average size is not a simple fraction of the maximum size even if this latter could be estimated objectively, which is not possible. Thus it would, I think, be reasonable to assume that the average weights given in the 1999 version were, overall, more appropriate than those in 2000 even though there are substantial problems with both versions.

In Tamura's 2001(2003) paper the values from Tamura & Ohsumi 2000 are used, except that an obvious error for the pygmy blue whale has been corrected. The totals for food consumption, and, naturally, fish consumption are inflated by 20-25% just by the unjustified changes in body size values between the original 1999 document and the later ones.

Evidently, the estimation of average body size introduces considerable uncertainty into the estimates of daily *per capita* food consumption. But we cannot provide a statistical measure for this uncertainty. There remain questions regarding exactly to what populations these averages pertain.

5. How many whales?

Per capita consumption figures related to weight, growth and age and sex composition have to be multiplied by estimates of population numbers. Those estimates are obtained by various methods, some much more reliable than others. The Eastern North Pacific Gray whales have for many years been reliably counted as they migrate close to North American shores. Minke whales in the Antarctic have, for over three decades, been visually counted in very extensive surveys by Japanese whaling vessels under IWC auspices and some supervision. Estimates published in IWC documents but not necessarily endorsed by the IWC or its Scientific Committee, for other species in the Antarctic come from incidental sightings of those species during the minke whale surveys; for some species. Certainly for the sei whale and possibly also for the fin whale these numbers are not accurate because their geographical distributions are different from those of the minke and this is likely to cause them to tend to be under-estimates. On the other hand, the parameters used in mathematical models for converting numbers seen to population estimates are not the same for all species, and they have only been calculated carefully for the minke whale. Numbers for other species in other areas have been extracted by Tamura and Ohsumi from the scientific literature, but most of those were obtained by methods of questionable validity[39] that would not be generally acceptable today.

Perhaps more important, however, is the fact that few of those estimates have been made specifically to count all size/age groups in the population; they are mostly of the adult animals that are vulnerable to whalers. Such estimates are not commensurate with the consumption estimates associated with values for average body size derived from the Trites & Pauly procedure.

Recent estimates from sightings surveys such as those for minkes in the Antarctic are based on complex mathematical procedures for converting numbers of animals *seen* to actual population estimates. This conversion is critically dependent on such factors as distance of a sighting from the survey vessel (this has not routinely been measured instrumentally, but only guessimated by the spotters), by how much the efficiency of spotting depends on the weather conditions at the time, how frequently whales surface to breathe and how long they stay there, visible, whether whales tend to approach ships or flee from them, or ignore them (and how much that depends on the behaviour of the ship). These and other factors vary, of course, considerably among the species but also with other conditions of the survey. So the results have wide statistical error ranges and some factors of bias.

Tamura used a value of 761,000 for the number of minke whales in the Southern Hemisphere, claiming that it is the number officially published by the IWC in 1991. In fact that number is simply the sum of figures for each of six Antarctic sectors ("Areas" in IWC terminology), obtained in six different years, a sum the Scientific Committee deliberately did **not** present.[40] Using this number gave Tamura the result that nearly 45% of food consumption by all baleen whales is by minkes, with the same percentage applying to both the crustacean and the fish component. This suggests that a close look at the validity of the 7-800,000 number is needed.

In 2000 the IWC published analyses by T.A. Branch & D.S. Butterworth of the results from the sequence of three circumpolar series of survey cruises from 1978/79 to 1997/98, including a revised estimate from the first series on which the Japanese preferred figure is based. These results were: 608,000 (instead of 761,000), 766,000 and 268,000. One has to wonder why, if Tamura preferred to use only the results of the first circumpolar series of surveys, he decided not to use the revised number, 608,000, which is 20% less than his?

In its Report of the 2000 meeting the IWC Scientific Committee wrote:
While the estimates of Southern Hemisphere minke whale population sizes totaling 760,000, which were obtained using IWC/IDCR data from 1982/83 to 1989/90 were the best available at the time for the years surveyed, <u>they are no longer appropriate</u>…estimates of current minke whale abundance. Extrapolations of the incomplete third circumpolar set of surveys [1991/-1997/8] led to a point estimate that was appreciably lower than the total of the previously agreed point estimates by Area… .

'The Committee also stated that it was:
unable to provide reliable estimates of current minke whale abundance.
That remains the situation in July 2006.[41]

Thus it is likely that the reliability of these survey results is much less than the published conventional Standard Errors/Coefficients of Variation suggest, but it does seem that the "best" estimate could be very much less than the 761,000 that Tamura and Ohsumi continue to use in their food consumption calculations, and that the ICR and Japanese Government put about in all their propaganda.[42]

What effect could such uncertainties have on the sorts of totals produced by Tamura? Obviously, in carrying through an exercise like that embarked upon by Tamura and Ohsumi one simply **has** to include the Southern Hemisphere minke whales, which are numerous and important, even if they do not eat fish; one cannot simply exclude them as T & O did with the N. Atlantic Bryde's whale. For such purposes most people would probably chose to use some sort of average figure. The average of the three minke survey estimates is 550,000. My scientific colleagues would not approve of such a simple calculation: the survey results have different standard errors calculated in the conventional way, and in other ways are not exactly comparable. One could make all sorts of adjustments, and until we know why the figures are so different we are not in a position to make rational choices. Still, suppose the real number is around 500-600,000. This would reduce Tamura's figure for total consumption by minke whales from 61m tonnes to 44m tonnes (i.e. by nearly 30%) and the overall total consumption by all baleen whales by the same amount, 17m tonnes.

However, the effect would not be the same with respect to the different types of food – fish or planktonic crustaceans. Those in the Southern Hemisphere according to Tamura - consume 83% of the total prey consumed by minke whales, and 93% of the crustaceans. But Tamura assumes that while those in the Southern Hemisphere do not eat any fish at all, fish comprise 59% of total food consumption by minkes in the North Atlantic and 70% of it in the North Pacific (average 61% in the entire Northern Hemisphere). Thus if those assumptions are correct – though the analysis presented in the *Primary* document shows that is unlikely to be so – errors in the Antarctic minke whale surveys will not affect the overall figures from ICR of total **fish** consumption by **whales**. They will however have a big effect on estimates of global prey consumption by all whales.

6. Dietary spectra

Examinations of the stomach contents of dead whales – whether those killed for commercial or "scientific" purposes, or by accidents such as being entangled in fish traps and collisions with ships, and naturally occurring strandings - tell us nothing about how much whales eat. Scientists hope, however, that they will learn from such autopsies something about the *composition* of the whales' diets, at least qualitatively but hopefully also quantitatively. There are however technical difficulties in doing that, especially the latter. For example, digestion begins immediately after the whale has swallowed food, but digestion of different types of food organisms takes place at different rates, and in different parts of the whales' guts. Small soft animals of course get digested relatively quickly and soon become unrecognizable to human observers. Very small items of diet can be overlooked altogether; for example the pteropods – very tiny pelagic "winged" snail- and slug-like molluscs - are rarely recorded despite being among the most abundant animals in the plankton in the areas where baleen whales feed, and long known by fishers and whalers to be important dietary elements in filter feeders. This problem of recognition and even rough quantitative assessment is particularly difficult under ship-board conditions in hostile environments. Data on diet composition from autopsies must therefore be regarded with circumspection. Fisheries scientists have long faced the same problems, and there is a vast scientific literature about this, completely ignored by Tamura & Ohsumi.

The more difficult question, however, concerns the representativeness of the stomach samples. Tamura 2002(2003) does not reference the sources of the dietary spectra (percentages of each food category) that he adopted. In one short paragraph he simply writes that he made "assumptions" and refers to a review of the subject by D. Pauly and collaborators.[43] I found that Tamura had in fact adopted all the values that had been used in Tamura & Ohsumi 2000. For the toothed whales, including the sperm whales, orca and North Atlantic bottlenose, the smaller whales and the dolphins, these were all taken from Pauly *et al.* The figures are rounded, they are the same in all three regions for those species that occur in every region, and most of them are little more than rough guesses. Tamura & Ohsumi chose, however to adopt, for the baleen whales, spectra from other sources, despite the fact that Pauly *et al* had also presented spectra for those species. I now look at their origins.

Tamura & Ohsumi used, for the entire North Atlantic, spectra from Sigurjónsson & Vikingsson (1998) except for the bowhead and Northern right whale, which came from Nemoto (1959), and for Bryde's whale from Nemoto & Kawamura (1977). The Bryde's spectrum was not used in the North Atlantic because of the lack of information about its population size, but the same values **were** used for the North Pacific. The spectra for the other baleen whales in the North Pacific came from Nemoto & Kawamura, except for the gray whale, from Pauly *et al*, and for the bowhead, again from Nemoto. The spectra for the baleen whales in the Southern Hemisphere are of less interest to us because Tamura & Ohsumi assume that with the exception of the Bryde's whale there they eat hardly any fish. For the Bryde's whale the spectrum comes from Kawamura (1980) and is split almost 50-50 between fish and crustacean zooplankton (But see the Annex).

The matter of dubious representativeness is well illustrated by consideration of the spectra used by S & V. But first I note that, notwithstanding the citation, the spectra assumed by Tamura & Ohsumi are not identical with those used by S & V. For example the percentage of the fin whale diet consisting of fish, used by the former authors, is 3.0, that by the latter is 2.2; correspondingly figures used respectively for the sei whale are 2.0 and 1.4%. These are small percentages but the effect is to inflate the estimates of fish consumption by these species by more than 50%. Likewise, S & V say 51% of the minke's diet is fish, but Tamura & Ohsumi, purporting to use the former authors' figures, instead use 59%, an inflation by16% for the species that Tamura & Ohsumi claim is responsible for 58% of the consumption of fish by baleen whales in this Region.

S & V's study concerned only the area around Iceland (northward to Jan Meyen Island and eastward to Faroes), and between Iceland and southern Greenland. However, their dietary spectra are even more restricted: the figures for fin and sei whales, for example, come exclusively from stomach contents of some commercially caught whales landed at the shore whaling station in SW Iceland, and which the authors note were still at that time not published.[44] There are many published data for baleen diet spectra in other parts of the North Atlantic, and they differ from each other enormously; those data were not used by S & V, who had a limited task anyway, but Tamura & Ohsumi applied the spectra for SW Iceland to the entire North Atlantic, from the Caribbean to the Barents Sea! They ignored the considerable amount of published data – much of it of higher quality than the unpublished Iceland data - for other parts of the Region.

We have seen above that Tamura & Ohsumi's figures for diet composition vary as between species, of course, and also, for particular species as between different Regions. We have also noticed that power functions relating food intake to energy requirements can only properly be applied if the species composition of the diet is known and taken into account by application of a wide range of appropriate values for energy density of the prey. Not only did Tamura &

Ohsumi ignore this requirement, they applied inappropriate gross figures differing only as between the Northern and Southern Hemispheres. Despite the fact that they decided that the Bryde's whale was apparently an abundant consumer of substantial quantities of fish in the Southern Hemisphere, accounting for 97% of their estimated fish consumption in that Region, they used an energy density figure which others have generally used for pelagic crustaceans. Of course, one consequence of this is to **inflate** their estimates for total food intake by whales globally, especially baleen whales, and particularly in the Southern Hemisphere. This, in turn, **inflates** the estimates of the amounts of **fish** consumed in the Region, mostly by Bryde's whales.

7. The Regions

Regional assessments should differ from each other by virtue of differing numbers of whales of each species, differing average body sizes (weights and/or lengths) and differing spectra of prey composition, with correspondingly different energy densities of the food consumed. The Tamura & Ohsumi documents do not adequately satisfy these needs except, partially, with respect to the assumed numbers of whales. The average size of each species is taken to be exactly the same in every Region. Some of the spectra of prey vary from one Region to another, but few of those differences are reliable, and they arise, at best, from data from small areas within each Region. The energy densities selected for use by Tamura & Ohsumi are unbelievable. They used a single value for all baleen whales in both Regions of the North Atlantic, and another value for all baleen whales in the Southern Hemisphere, and the same one for the toothed whales everywhere, regardless of whether a species is judged to be eating only crustaceans, also some fish, or mostly fish and/or squids.

Tamura & Ohsumi compare these meaningless results with FAO landings statistics which relate to quite different definitions of the three Regions. The FAO-based North Pacific, for example, compiled by these authors, is the total of four FAO "Statistical Areas" which extend far into the Southern Hemisphere, down to 25°S at its centre and on its western side, i.e. to Brisbane, Australia, which includes breeding grounds of baleen whales from the Pacific sector of the Southern Hemisphere populations!

In view of these considerations there is no point in trying to draw any useful conclusions from Tamura & Ohsumi's so-called "Regional Assessments".

8. Other questions

Like other mammals and vertebrates, and, indeed, such invertebrates as have been studied, whales have evolved to select their food carefully. Evidently, finding sufficient caloric energy is a fundamental need, but there are others, subtler, such as protein, fats (lipids), minerals and other materials needed in appropriate quantities. Baleen whales do not just swim about with their mouths open, taking in just whatever is there; they select the feeding location and have complex feeding behaviours we humans are only just beginning to learn about.

When a species of whale foraging in a particular locality and in a certain season is found, from examination of the contents of its stomach, to have a certain apparent dietary spectrum, it would be naïve in the extreme to suppose that this is its typical and unchanging diet. In particular, although whales, fishes and most if not all other animals are influenced in their diet by what foods happen to be present, they equally do not simply ingest what are present in the proportions in which they **are** present; such a naive assumption is one of the basic flaws in early attempts at multi-species modeling of marine and other ecosystems. However, it is equally sure that if a population of one species of whale is found to be feeding on both fishes and planktonic crustaceans, observed in a certain proportion, that proportion must be expected to change if, for example, the abundance of the fish is drastically reduced by fishing operations; we must expect the whales, as far as possible, to change their foraging locations and behaviours to compensate for this. Such shifts will change the dietary spectrum and hence the overall energy density of the food ingested.

An unmeasured proportion of the consumption of fishes by baleen whales calculated by Tamura & Ohsumi consisted of species of direct interest to humans, being the targets of important commercial fisheries – herring, cod and haddock, anchovies, saury, capelin, etc. But equally, an unmeasured – or, at least, unreported - proportion was of species of no commercial interest, and even some that are competitors with the species of commercial interest or predators on them. The problem is not solely with species distinctions. The sizes of, for example, cod and haddock, found in some samples in the North Atlantic, were not the same as the sizes of those species taken by fishers. The practical significance of such differences becomes obvious when one realises that some of the larger fish species found occasionally in the stomachs of baleen whales are “cannibals”. Cod is a well-known example - feeding on their own young. And it is at least theoretically possible that the feeding of some whales such as the Bryde’s whales, in warm waters, on small pelagic fishes, involves consumption of some of the foods of other, much bigger fishes of commercial interest, such as tunas, and other fishes of lesser or no commercial value. But Tamura & Ohsumi provide no evidence of any of these processes, which are central to interpretation of their consumption figures.

So, whatever revised quantities of consumption by baleen whales that we might come up with after the critical analysis I have presented here and in the *Primary* document, it should be understood that they have very little meaning with respect to the interactions between whales and humans, and contribute little or nothing to solutions of such problems.

9. Recapitulation and conclusions

The propaganda disseminated by agencies of the Government of Japan about the “vast amounts" of “marine resources” consumed by whales and dolphins has *tactical* purposes in justifying continually expanding and diversifying unregulated commercial whaling by issuance of Special Permits for scientific research, and in persuading Governments of countries having no great interest either in whaling or in research on cetaceans to join the IWC and vote with Japan on a variety of issues. The *strategic* purpose of this propaganda is, however, to throw the "moratorium" on commercial whaling" (i.e. the setting of all catch limits for species and populations to zero, indefinitely), adopted by the IWC in 1982, into disrepute and, further, to justify not merely the early resumption of commercial whaling but its expansion again to unsustainable levels. From the point of view of **profitable** whaling on both residual and relatively abundant stocks and species, that makes sense.[45]

The 1982 decision practically only affected the immediate future of minke whaling. Zero catch limits had before that been set everywhere for all other species of baleen whales except Bryde's, (as well as for the sperm whale), and some stocks of minke whale, based on the findings of the IWC's Scientific Committee that they were "depleted" and should therefore be given "Protection Stock" status in terms of the so-called New Management Procedure (NMP) that had been agreed in 1975. The Scientific Committee and the Commission itself had also declared the minke whales in the Northeast Atlantic to have been depleted by decades of Norwegian whaling, but the Government of Norway had legally "objected" to that decision and continued its whaling operations unilaterally. However, commercial catching of minke whales in the Southern Hemisphere had only begun in the early 1970s, when the larger species had been depleted, so although their numbers were not then known it was presumed they had not yet been much reduced by whaling. The "moratorium" was an insurance against further depletion, in the absence of sound management measures. The Commission's decision in 1994 to create a vast Sanctuary in the Southern Ocean reinforced a "precautionary approach" by closing to whaling the feeding grounds of the baleen whales of the Southern hemisphere; the breeding grounds of some of those populations had already been closed, in 1979, by a corresponding decision to designate the Indian Ocean as a sanctuary.

The calculations presented by ICR scientists and the Fisheries Agency of Japan suggest that the **baleen whales** in their present numbers **consume, world-wide, about 14m tonnes of a variety of species of fishes** We have seen that the Regional breakdowns of that quantity given by Tamura & Ohsumi, whether species-by-species or overall, are meaningless and should be ignored. Numerous sources and types of error and of bias in those calculations have been identified. What do they amount to?

Of three methods of calculation used by Tamura & Ohsumi only one – their Method 2 – derived from Innes *et al* via Sigurjónsson & Vikingsson, is valid in principle. Their undocumented and unexplained increase in the power exponent from 075 to 0.78, without a compensating decrease in the "constant" multiplier, inflates all consumption estimates by a small amount - 4-5%. More to the point are upward adjustments made by a succession of authors to the multiplier. These include a digestion efficiency of only 80%, based on the erroneous assumption that baleen whales cannot digest chitin in the carapace of crustacea, **but nevertheless applied to all food items**. In addition, again by several previous authors, conversions were made for energy needs from basal and resting metabolism figures to "active" or "normal life" metabolism (by an "activity coefficient" of 1.5, i.e. adding 50% to the basal metabolism) which might be reasonable but was done twice; that is the "correction" was squared. That inflated the consumption figures by more than another 50%. Multiplication of estimates of daily energy requirements by 365 introduces a further probable upward bias and additional uncertainty, at least as far as the migratory baleen whales are concerned.

Changes made to the figures used for the average weights of whales of each species, from the 1999 to the 2000 document by Tamura & Ohsumi (which were carried over by Tamura) further inflated the global figure for consumption of both fishes and planktonic crustaceans by the baleen whales by 30%. The figures in 2000 came from Trites & Pauly, 1998; they are incredible, inappropriate and simply wrong, being derived from mere guesses as to the largest sizes and highest ages of each whale species and an assumption that the population age composition is natural and like that of humans, instead of having been drastically affected by exploitation during the 20th Century.

These are all upward biases to estimates of metabolic needs of the whales. Since the final figures are the arithmetic products of a series of upwardly biased calculations and choices of data and method it is clear that they are roughly double or even triple what the limited data justify. The next stage is the conversion of energy needs to biomass of food. This should be done by determining the spectra of types of food consumed and applying to those a range of appropriate estimates of energy density. Tamura & Ohsumi performed this calculation in the wrong order, using inappropriate "average" energy densities regardless of what the whales were actually found to be eating.

The energy densities of a variety of fish species and of crustaceans (euphausids, amphipods and copepods) vary over a four-fold range, at least. It is therefore essential to use appropriate values, tailored to observed diets. Tamura & Ohsumi chose to use rather low values for the energy density of plankton, which – by their procedure – inflates the figures for total food consumption, and hence for consumption of fishes.

Figures for total food consumption are proportional to the estimates of population numbers of each species. It is remarkable that notwithstanding two decades of intensive visual surveys of minke whales in the Southern Hemisphere there continues great uncertainty as to their numbers, over a two- to three-fold range. Tamura & Ohsumi, and spokesmen for the Government of Japan, continue to use the older, highest values for their calculations despite the fact that the IWC Scientific Committee has declared that it now has no valid estimate, and has published the more recent figures, the most recent and lowest of which is less than one half of the figure used by Tamura & Ohsumi. The Committee is unable to say if the minkes have actually declined or if other unknown factors have seriously affected the survey data. The Japanese Authorities' insistence on using the earliest high estimates substantially inflates not only the figures for the southern minke, but also those for the baleen whales as a whole because the minkes, being numerous if individually relatively small, account for a large percentage of the baleen total.

Finally, the particular estimations of quantities of fish consumed, derived from highly variable percentages of dubious authenticity, are based on enormously variable **and selected** data that – at best – relate to limited localities in each ocean region. The dangers of doing that are illustrated by the fact that stomach contents analyses from neighbouring whaling stations, through parallel series of years, can indicate completely different diet compositions, as demonstrated vividly by E. Mitchell many years ago with reference to Canadian operations in the St Lawrence-Newfoundland area.[46] And most of the Regional estimates are based on selected and unrepresentative information from a limited part of the Region, including especially samples from areas of intensive fishing and even from whales trapped in fixed fishing nets – which of course will be found to have been eating fish!

All in all it would be in accordance with existing data, and reasonable, to say that the baleen whales might consume annually 5-7m tonnes, or less, of fish, and that associated with that number is a very high but unquantifiable statistical error. That is less than one tenth of the human landings. To suggest that this consumption is in any way and to any degree responsible for the current crisis in world sea fisheries is obviously nonsense. The about nine times bigger consumption of zooplankton is of little if any consequence to human activities and aspirations.

Nonsense can, of course, be ignored. But it can also have pernicious effects. One of these, in the present context, is diversion of attention and energy from the real problems confronting the IWC. Another is to divert attention from the real causes of the fisheries crisis, *viz* widespread and chronic over-fishing and perhaps some environmental deterioration.

It would be entirely wrong to think that if the exterminations of the baleen whales were now to be completed, fish landings would miraculously increase by anything up to 10% - if at all. Some as yet undetermined fraction of the fish now being consumed by these whales is of species of no current interest to humans, and some are themselves competitors with, or predators on, those species that **are** of interest. Furthermore, humans and whales are not the only consumers of the commercially interesting fishes; in fact the main predators on fishes are other, bigger fishes, supplemented by predation by squids, jellyfishes, seabirds etc. And, lastly, in the present state of fisheries management any potentially beneficial increase in the abundance of desired species, however unlikely of tiny, would very quickly be cancelled by more over-fishing!

At this point it is relevant, I think, to be reminded that while the UN Convention on the Law of the Sea (UNCLOS) – which is now the ultimate authority for what the IWC may and may not do – does not specifically authorise the "culling" of predatory species in order to enhance catches of their prey, it **does explicitly** require that management of exploitation of prey species be conducted in such a way as not to diminish the biological productivity of the predators – so-called ***dependent species*** – by leaving them insufficient food. Many of the populations of small pelagic fishes that some baleen whales prey upon have now been depleted by intensive and poorly regulated (or unregulated) commercial fishing (particularly for fishmeal production). But it has to be said that there is as yet little sign of the signatories to UNCLOS complying with its provisions on this matter. At the same time it is worth recalling that the UNCLOS does explicitly empower management organizations such as the IWC to take more conservative regulatory actions regarding the exploitation of marine mammals, and especially the cetaceans than is mandated for fines and shellfishes.

The fairy story about the whales being enemies of humans, told and retold by those who are anxious to engage in unsustainable whaling or otherwise benefit from the Japanese-Icelandic-Norwegian strategy in the IWC, is not, of course, the only such story in their repertoire. The St Kitts and Nevis Declaration is virtually a catalogue of such tall stories. That is the subject of another critique in preparation. But a common thread is the gross distortion of the history of IWC actions over the last thirty years or so. That history is embedded, nay, buried, in the verbatim records of IWC meetings, in the long and extremely complex – and, I would say, opaque – Reports of the Scientific Committee, and in the archives of papers submitted by governments to the IWC on its core agenda items. It is obvious that few of the delegations to the St Kitts and Nevis meeting who co-sponsored the Declaration knew anything about that history beyond what they had been told in briefings by the Japanese agents who recruited them. Or, if they did know the history and the relevant facts, they chose to ignore them in taking political decisions with other aims than "normalisation" of the IWC. If some of them, after reading this document, realise they have been the victims of a confidence trick, and resent that, so well and good. It would be even better if they come to see that they have been misled in other ways, too, especially with respect to the prospects for managing any future commercial whaling.

The question of what happens in and to an ecosystem – or indeed any network - when certain elements of it are removed or otherwise changed is a profound and important one, with many practical and theoretical implications. It deserves the attention of serious science.

"***Understanding is, after all, what science is all about – and science is a great deal more than mere mindless computation.***"

Roger Penrose, cosmologist, mathematician and tile designer[47]

ANNEX

The Case of the Southern Hemisphere Bryde's Whale

There follows an extract from a monograph in preparation[48]

Japan's Contribution to the Loss of Whales:
A Historical Analysis of Japan's policy and of its Strategy and tactics in Pursuit of that Policy

2.7 Practicing scientific whaling II[49]
We now jump forward twenty years to the third millennium when Seiji Ohsimui wrote, with co-author T. Tamura, a batch of papers (dated 1999, 2000 and 2002) claiming that the baleen whales consume huge quantities of fishes, many of commercial interest to humans, and are therefore serious competitors with fishing industries. These have been critically examined elsewhere. Here we are interested especially in the contribution of the Bryde's whale to this presumed competition, particularly in the Southern Hemisphere. The figures for the numbers, sizes of whales and their food consumption vary somewhat between the above three publications and here we shall focus only the 2000 paper made available to, but not discussed in depth by, the IWC SC. In the critique mentioned it is demonstrated that virtually all the consumption figures given by Tamura and Ohsumi are gross exaggerations of what the actual existing data and methods of analysis might justify. But here we focus solely on their statements about the Bryde's whale.

First, to gain perspective, we note the claim that baleen whales worldwide consume 146 million tonnes of "marine resources" annually and that 15 million tonnes of that, *i.e.* about 10% is fish. Of the total consumption 100 million tonnes (*i.e.* 69%) is said to be consumed in the Southern Hemisphere, and of *that* 6% is fish, *i.e*. 6.8 million tonnes, the remaining 94% being planktonic crustaceans – mostly euphausids but also copepods and amphipods..

Of the global 146 million tones 16% is said to be consumed by Bryde's whales, and it is claimed that *their* diet consists of 38% fish and 62% crustaceans so *they* consume 6 million tonnes of fish annually. But in the Southern Hemisphere the Bryde's whale diet is said to consist of 47% fish and 53% crustaceans, so it turns out that in the Southern Hemisphere Bryde's whales are "accused" of consuming 5.6 million tonnes of fish. The corresponding figure for the North Pacific was 11% fish and 89% crustaceans.
So, the question to be asked is: from where comes the 47-53% dietary spectrum?

The North Pacific diet figures for Bryde's whales come from a 1977 paper by T. Nemoto & A. Kawamura, but the Southern Hemisphere dietary spectrum for this species is cited as coming from a paper by Akito Kawamura published in 1980. **Dr Kawamura had been commissioned to analyse the stomach contents data from the three years of Special Permit whaling (conducted in the 1970s in the**

Indian and Pacific Oceans).. He had concluded that "the Bryde's whales in pelagic waters of the Southern Hemisphere largely prey upon the euphausiid crustaceans instead of the fish." These findings generally confirmed the provisional conclusions Ohsumi had originally presented to the IWC SC in 1979, so they certainly do not support the claim in the Tamura & Ohsumi papers that nearly half the diet consists of fish. In an earlier paper on the stomach contents of whales taken in the first Special Permit whaling season (1976/77) Kawamura was emphatic that the stomachs that had food remains in them (many did not) contained absolutely nothing except euphausids, and he devoted much attention to comment on the relative frequencies of three species of these zooplankters and differences between the Coral Sea samples, those from the waters between Fiji and New Zealand, and those from near Madagascar. He also makes interesting comments about the relative lack of overlap with the diets of some of the larger predatory fishes in the same areas. These fishes – albacore, yellowfin tuna and skipjack – were feeding on microplanktonic fishes (60%), euphausids (7%, or 12% if one counts the euphausids in the stomachs of the prey fishes), the rest being small pelagic squids.

The puzzle is resolved by looking at other publications on Bryde's whale diet. The most important of these, as far as the Southern Hemisphere is concerned are a series by P. Best, published in 1960, 1967 and 1977 on the stomach contents of Bryde's whales examined at the South African land-stations at Durban and Donkergat. Some of these do indeed show high percentages of fishes in the stomachs, but Best concluded , from morphological study, that two different forms of Bryde's whale were being caught there, one an inshore form that was eating mainly fish and the other an off-shore form consuming crustaceans. Tamura and Ohsumi chose to use the South African inshore data for application to the entire Southern Hemisphere instead of the data from the Special Permit studies that Ohsumi himself had collected. **The result was a 15-fold inflation of the fish consumption by Bryde's whales and a 13-fold inflation of the estimates of total fish consumption in the Southern hemisphere by all baleen whales.**

Notes and Sources

[1] The nonsense is not limited to the issue of whales eating "our" fish. It includes, for example, graphics – with no supporting citation - purporting to show that minke whales increased many-fold during the 20th Century, for which there is not the slightest scientific evidence.

[2] As reported, for example, in *The Sunday Times*, London, 18 June 2006. Similar statements are contained in numerous brochures distributed by the ICR and the Government of Japan.

[3] Tamura, in his 2003 FAO paper referred to below, is rather more cautious and precise. In the abstract of his paper he wrote: "The total annual **prey** consumption by **cetaceans** in the world was estimated to be **at least 249-434million** tonnes." [My emphases] He cites the FAO statistics for his reference year 1996 as a **fisheries** catch (more precisely ***landing -sjhs***) of **87m** tonnes. That is the sum of FAO's categories 'marine fishes', 'cephalopods (squids, cuttlefishes and octopi)' and 'crustaceans', plus nearly 4m tonnes

of "others" (Tamura's category). The statement about "3 to 5 times the fish catch" is a massaged version of a corresponding statement in Tamura & Ohsumi 2000 (see below) and follows the line expressed in propaganda materials distributed by the ICR and other official Japanese agencies. Tamura's estimates of **fish** consumption by all **cetaceans** range from **57m** to **78m** tonnes. His estimates of squid consumption by cetaceans range from **77m** to **122m** tonnes, mostly by sperm whales but with substantial contributions by beaked whales in the Southern Ocean, and by pilot whales. The figures for "crustacean" consumption, mainly by baleen whales, are not comparable with the fisheries catches going under the same name; while zoologically correct those crustaceans consumed by whales are all tiny planktonic animals such as krill (euphausids) and copepods ("water fleas"), while the catches by humans are nearly all of much larger and mainly bottom-living species such as crabs, lobsters and shrimps.

[4] St Kitts and Nevis Declaration. Document IWC/*58/16Rev*. The co-sponsors of this Resolution were: St Kitts and Nevis, Antigua and Barbuda, Benin, Cambodia, Cameroon, Cote d'Ivoire, Dominica, Gabon, Gambia, Grenada, Republic of Guinea, Iceland, Japan, Kiribati, Mali, Republic of the Marshall Islands, Mauritania, Morocco, Nauru, Nicaragua, Norway, Republic of Palau, Russian Federation, St Lucia, St Vincent and Grenadines, Solomon Islands, Suriname, Togo and Tuvalu.

[5] A favorite theme – repeated in the St Kitts and Nevis Declaration - of the Governments of Japan and its allies in the IWC is that measures such as the 1982 decision to set all commercial catch limits to zero, and those of 1979 and 1994 to establish whale sanctuaries, were made "without the advice of the Commission's Scientific Committee that such measures were required for conservation purposes." and were therefore in some way illegitimate or even contrary to the 1946 International Convention for the Regulation of Whaling. Article V(2)b of the Convention states that such decisions "shall be based on scientific findings" and the Commission has never accepted a restricted and perverse interpretation of that requirement such as that repeatedly insisted upon by Japan. Those controversial decisions did in fact fulfill that and other statutory criteria, as the records of the Commission and its Scientific Committee clearly show. But of course the Committee could never *recommend* such actions because it consists of scientists appointed by, and each responsible to, their governments. It is of interest in the present context that this demand that the Commission not act except in response to a specific recommendation from its Scientific Committee was not reflected in the votes by those same Members for the St Kitts declaration. (See below); the paragraph "Accepting that scientific research has shown…" does not reflect any statement or discussion, at any time, within the Scientific Committee, and is also contradictory to most scientific opinion outside the Committee.

[6] The other governments, Members of IWC, that voted for these and other "economies with the truth" in the so-called St Kitts and Nevis Declaration, apart from the co-sponsors of the Resolution, listed above, and Denmark, were Senegal and the Republic of Korea: China abstained.

[7] I have reviewed the history of these actions and given an account of Japan's strategy in "Viewpoint: Propaganda and Pretext" *Marine Pollution Bulletin* **52** (2006): 363-6.

[8] "Regional Assessments of prey consumption by cetaceans in the world", *IWC Doc. SC/52/E6*, 2000, included in an undated compilation by the Fisheries Agency of the Government of Japan, entitled "Increasing Competition Between Fisheries and Whales: Japan's Whale Research in the Western North Pacific (JARPN II)" that was distributed during the meeting of FAO's Committee on Fisheries (COFI), Rome, March 2005. Also "Regional assessment of prey consumption and competition by marine cetaceans in the world" by T. Tamura, 2003 as Chapter 9 of a book edited by M. Sinclair and G. Valdimarsson "Responsible Fisheries in Marine Ecosystems" (FAO and CABI Publishing, Wallingford, UK, p 143-70). That book originated as the Proceedings of an

international conference on the title subject held in Reykjavik, 1-4 October 2001, sponsored by FAO and the Government of Iceland, supported by that of Norway. Although my analysis focuses on documents produced and distributed by the ICR, related misleading and erroneous papers on the same subject have emerged elsewhere, particularly from the Institute for Marine Research, in Iceland, under the authorships of Drs J. Sigurjónsson and G. A.Vikingsson. Reference is made to those where relevant in the primary document.

[9] See, for a commentary on this, "Sustainable Use of Ocean Wildlife: What lessons can be learned from commercial whaling?" by V. Papastavrou and J. Cooke, pp113-28 *in* "Gaining Ground: In pursuit of ecological sustainability", *Ed*. D. Lavigne. University of Limerick Press and International Fund for Animal Welfare, 2006.

The IWC workshop had a strange history. It was originally proposed by the delegation of Japan and was to have been held in St Lucia. The Government of St Lucia later backed out from its offer to host the workshop, and at the last moment the Government of the USA arranged for it to be held in California. But it was then boycotted by Japan and no Japanese scientists participated. It is widely presumed that there was no wish for the Japanese claims about the impact of whales on fisheries to be scrutinized, on neutral ground, by other scientists.

[10] Richard Robinson, 2005. "Why the toast always lands butter side down: The science of Murphy's Law" Robinson, London, pbk. A pantomime is an English traditional Christmas play for children, the scenario of which always follows a set pattern, and involves interactions between players and audience.

[11] FAO Yearbooks of Fishery Statistics: Capture Production. Rome.

[12] It might reasonably be assumed by readers and listeners that when Japanese spokes-persons quote ranges of numbers they are implying some kind of statistically defined range of error. But no such calculated ranges are given in any of the referenced documents.

[13] In giving rounded figures here I have chosen to quote the most recently distributed document, that by Tamura in the FAO volume. Figures differ in detail as between the Tamura and the Tamura & Ohsumi documents, but not sufficiently to worry us much here. However, Tamura does not cite, in his FAO document, the sources of his data pertaining to, for example, the assumed mean weights of whales of each species; for that information it is necessary to resort to the Tamura & Ohsumi document and, further, to the sources they cite.

[14] This species was nearly exterminated, in the decades following World War II, by Norwegian whalers in an unregulated industry the principal commodity from which was pet food. Exploitation of three other similar bottlenose whales – the Baird's beaked whale of the North Pacific and the Southern bottlenose and Arnoux's beaked whale of the Southern Ocean – is not regulated by the IWC because their common names were not included in a multilingual list of species of "whales" attached to the Final Act of the 1946 Convention under which the IWC is established, although they **are** listed in the Convention itself. This bizarre situation arose because the Convention does not specifically define "whale" or "whaling", Japan, as an occupied country did not attend the 1946 conference so no Japanese names were listed in the Nomenclatural Annex to the Final Act. Japan did not, later, want its industry catching Baird's beaked whales to be regulated internationally, and Denmark came up with a legalistic reason for excluding these and many other species since it did not want regulation of lucrative Greenland and Faroes commercial whaling for narwhal, beluga and pilot whales. In the absence of statutory definitions the IWC is limited in such decisions to those attracting consensus of all Parties to the 1946 Convention.

[15] It is remarkable that while the ICR and its associates provide consumption figures for all cetaceans, in order to inflate the totals they wish to compare with catches by humans,

Japan, Norway and Denmark have for thirty years been the most active states in opposing acceptance of the smaller species as being within the responsibilities of the IWC. In fact in the 1970s, after the UN call for the IWC to consider adopting a ten-year moratorium on commercial whaling, the Norwegian authorities clung to the fiction that the six to seven-tonne minke whale – the last target of the commercial whalers – is a "small cetacean"! Japan, Norway, Iceland, Russia and their allies in the 2006 St Kitts meeting sought the passage of a resolution prohibiting the IWC Scientific Committee from even discussing the smaller species, but they failed to attract a majority.

[16] Here and in the following remarks I sometimes refer to numbers that are not contained as such in Tamura's published paper and the Tamura & Ohsumi documents, but they are strictly derived by simple arithmetic from the numerical information those authors tabulate.

[17] For the sperm whale there are huge discrepancies among the results by the three methods. For example a total consumption of 64.7m tonnes by Method 1 and 156.4m tonnes by Method 3. The **guessed** percentage allocations (dietary spectra) among fishes, cephalopods and crustaceans are the same in all their calculations, by method and by region.

[18] In addition to the huge blue and fin whales I refer here to the other *rorquals* (the fast-swimming Balaenopterids) which include the sei, pygmy blue, Bryde's and two (or perhaps three) species of minke whales, and to the humpback, the grey whale of the Northeast Pacific (the only baleen whale that is, at least partially, a bottom feeder on small shellfish and worms) and the several species of the now rare right whales (bowhead, North Atlantic right or Biscay whale, and the Southern right whale.)

[19] In the ICR documents the ocean is divided into three Regions: the North Pacific, the North Atlantic and the Southern Hemisphere, including the small part of the Indian Ocean lying north of the equator. Those regions are not commensurate with the three regions of FAO's marine fisheries catch/production/landings statistics to which the ICR gives the same names. (See below)

[20] Tamura & Ohsumi's treatment of the two Southern Ocean species of bottlenose whales is a remarkable example of how misleading are their conclusions. They group the two species together as **beaked whales,** with a combined number of 600,000, an average body weight of 1.4 tonnes and a dietary spectrum of 40% fishes, 45% squids and 15% crustaceans. This spectrum is a combination of **assumed** spectra of 60-30-10 for Arnoux's beaked whale (average body weight used 1.7 tonnes), and 20-60-20 for the Southern bottlenose (body weight 1.1 tonnes). The combination is a simple average, implying that the two species exist in equal numbers and are the same size. The overall number is a single estimate derived by ICR from some incidental sightings of unidentified beaked whales during the first series of Antarctic minke whale surveys conducted under IWC auspices. The IWC Scientific Committee never accepted that estimate. Little more is known about these species except their anatomy, and even that not very well. Yet on this frail "evidence" Tamura & Ohsumi claim that the two species eat 4.0m tonnes of fishes and 4.6m tonnes of squids, accounting for a little less than one fifth of their estimate of fish and squid consumption by **all** cetaceans in the Southern Hemisphere!

[21] Tamura concluded that 0.1m tonnes of cephalopods are consumed by baleen whales (less than 0.1% of the total); all these are said to be by fin and sei whales in the North Pacific.

[22] According to Tamura 5000 pygmy blue whales, of average weight 69 tonnes, consumed 2.1m tonnes of planktonic crustaceans, while a slightly lesser number (4885) of ordinary blue whales, of average weight 103 tonnes, consumed 2.5m tonnes. This a significant change from the earlier documents by Tamura and Ohsumi in which the pygmies were assumed to be the same size as the large species! This arose from use of a

bizarre method of estimating average body weights indirectly. Calculations for several other species are subject to the same sort of error, though not on such a grand scale.

[23] The sei whale was once numerous in all oceans, but was not until late in the history of "modern whaling" distinguished by whalers from the Bryde's whale. (Its average body weight is said to be about 17 tonnes, compared with Tamura's use of 16 tonnes for the Bryde's). In the Antarctic intense exploitation of sei whales began only in the 1960s, after the blue, humpback and fin whales had been nearly exterminated; when the seis had been depleted exploitation of the minke whale began, around 1970. Tamara estimates that the remaining sei whales consume, world-wide, about 49 thousand tonnes of fish, comprising 1.6% of their diet The crustaceans they eat are not all or even mainly krill (euphausids), at least in the Southern Hemisphere. In that Region, generally feeding further north than the fin, minke and blue whales, they also eat quantities of copepods, which are much smaller than krill. They probably also eat significant but unmeasured quantities of "pterapods" – tiny planktonic 'slug-' and 'snail-' like mollusks.

[24] Although Tamura's figures for total fish consumptions by the minke and by Bryde's whales are similar they derive from quite different features. The minke is assumed to number nearly one million individuals, with an average body weight of just over 6 tonnes; there are only about 120 thousand Bryde's whales, but with an average body weight of 16 tonnes and, he assumes, with a much higher proportion of fish in their diet.

[25] It is not generally realized, nor remembered, that at the time the general commercial moratorium was adopted by the IWC – formally by setting zero catch limits for all species and stocks - there were already in place zero catch limits for practically all species and stocks of large whales except the minke. This situation arose from the application of the New Management Procedure (NMP), adopted in 1975, under which all populations ("stocks") judged to have been reduced to be below about half of their original – pre-exploitation – number were classed as "Protected". There were also zero catch limits for some stocks of Bryde's whales because of a precautionary feature of the NMP which required zero limits to be set in the absence of acceptable data for population number. Legally and practically, therefore, the 1982 decision affected mainly minke whaling.

[26] Tamura cites a figure of **86m** tonnes in his base year, 1996, but that includes more than 1m tonnes of oysters, mussels and clams among the broad category "marine molluscs) Most of that is of course shell and it takes a large stretch of the imagination to suppose that whales are competing with humans for them.

[27] The uncertainty here comes from the fact that the FAO statistics include a large "Miscellaneous" sub-category.

[28] This is not such a huge error, as it might seem since the energetic considerations in using their Method 2 do not explicitly take into account the intake rates during the feeding seasons that lead to enormous accumulation of fats in the blubber. It is possibly appropriate to consider the apparent upward bias in the annual figures obtained this way more as a contribution to very high uncertainty of their overall results.

[29] If for example, the value of the dependent variable (in our case the food consumption) is proportional not to the independent variable (body weight) but to its square root then the value of the **power exponent** would be 0.5, in which case the food consumption increases more slowly with increase in body size. The power exponent estimated by Innes *et al* from Sergeant's data was 0.67, so consumption increases with body weight in proportion to the two-thirds power of the weight.

I re-analyzed the same data by what I think is a more appropriate method and obtained a power exponent of 0.75. This happens to be in accord with the modern view that rates of metabolism - at least of vertebrates – (and particularly basal metabolism) are proportional to the 0.75 power of the body weight.

[30] If my revised estimate of 0.75 for the exponent had been used the results would have tended to be rather closer to those from Method 2. However, the differences between results depend in detail on the value used for the constant in the power function, whatever might be the value of the exponent.

[31] It would be fair to note here that S & V, whose methods Tamura and Ohsumi copied, also used questionable data uncritically. Their concluding words were "The results show that the total biomass consumed (by cetaceans around Iceland) is substantial, or more than three times the total landings of the Icelandic fishing fleet." J. Sigurjónsson and G. A. Vikingsson (1998) "Seasonal Abundance of and Estimated Food Consumption by Cetaceans in Icelandic and Adjacent Waters" *J. Northwest Atl. Fish. Sci.* **22**: 271-87.

[32] The 1.11 figure implies – on the basis of the S & V procedure, that the baleen whales in the Southern Hemisphere are, overall, consuming a diet of about half fish and half crustaceans.

[33] I bear some responsibility for that; I collaborated with Dr Lockyer in the 1970s.

[34] It is not always realized that small differences in length of an animal imply large differences in weight. For example when catching of the huge blue whale was begun in the Antarctic the average length of caught whales was as high as 95ft (30 metres) But in a few years the average had become reduced to less than 80 ft. A 95ft whale is nearly twice as heavy as an 80ft one.

[35] That assumption is not as bizarre as it might seem.

[36] Trites & Pauly were aware of the shortcomings of their method in the absence of reliable data. They wrote *We were not able to substantiate the maximum lengths reported in the species compilations by Klinowska (1991) and Jefferson et al (1993). Original data sources should be consulted wherever possible, given the wide range of unsubstantiated maximum lengths reported for many marine mammals on the World Wide Web and in the published literature. Humpback whales, for example, have been reported to have a wide range of maximum lengths. Unfortunately a number of the cited lengths are incorrect, such as the 75 ft humpback that was actually a fin whale!* Klinowska's and Jefferson *et al*'s compilations were certainly not made in such a way and with such care as would be needed for the application of the Trites & Pauly formula for Tamura's purpose. It is also worth noting that Trites & Pauly's calculations for the blue whale used information about females, and they simply *assumed* that the maximum length of a male would be 5% less (implying a body weight about 14)% less. The origin of the Tamura & Ohsumi figure for the pygmy blue whale remains mysterious, since Trites and Pauly did not deal with that species A final word on this matter can be given to H. Whitehead who has studied sperm whales for most of his working life: *How long do sperm whales live? I am afraid that, once again, our ability to answer a question about a population parameter is limited by aspects of the whaling industry and the science based on it, as well as by the constraints of modern studies. Many of the sperm whales that lived in the second half of the twentieth century were killed by humans, but scientists began estimating ages, using tooth layering, only towards the end of the catch, by which time most of the older animals had probably been killed. Also, the closure of the pulp cavity within the tooth as animals age makes it hard to discern some layers, so that older animals cannot be accurately aged.* The same can be said about the figures for maximum ages of baleen whales and age determinations from their earplugs.

[37] Remarkably, Tamura does not reference the two documents he co-authored with Ohsumi. Furthermore, he did not provide the Reykjavik Conference and FAO with details of how he arrived at his figures; for that information one must go back to his earlier papers co-authored with Ohsumi. He also does not tabulate the average weights used; I deduced them from his figures for numbers of whales and population biomasses.

[38] The global averages for the humpback and sei – 30 and 17 tonnes respectively – did not alter because of changes in the figures used for their numbers in one or other Region.

[39] Mostly from tagging experiments or from observation of the rate of decline in catch-per-unit-effort related to time-series of catch statistics. A few of the smaller toothed cetaceans have been surveyed acoustically, but only in small areas of their geographical distributions.

[40] The methods of survey were not exactly the same in each year. Tagging experiments have shown that some baleen whales move from one sector to another in successive years, so there can be both under- and over-counting.

[41] The above statements were agreed by consensus. I leave it to readers to think what to make of continued insistence by Ohsumi, Tamura, the ICR and the Government of Japan that there are more than 700,000 minke whales feeding in the Antarctic. The actual numbers in the three surveys given by Branch & Butterworth were 608,000 for the first survey (as compared with the original figure); 766,000 for the second; 268,000 for the third. The Scientific Committee noted that the third estimate is, statistically speaking, significantly lower than the second. In the first series 61% of the ice-free area south of 60°S was surveyed; in the third series, 65% So the huge difference in results is not due to a big difference in area coverage. The second survey covered 85% of the ice-free area south of 60° so one might expect the results to be somewhat higher – but not, proportionately quite so much higher. Branch & Butterworth offer hypotheses as to why these figure might be under-estimates of the numbers of minke whales – there might be whales in ice-covered areas that could not be reached by survey vessels; some whales on the vessels' tracks might not be seen; some minke whales do not migrate as far south as the surveys limit of 60°S. It is also possible that the number of whales has, for unknown reasons, actually declined between the first and second survey series and the third.

[42] Papers presented to the Scientific Committee in June 2006 gave further revised figures for minkes from the three survey sets: 645,000; 786,000; 338,000. It was pointed out that although there was an apparent decrease in the number of minkes, other species (fin, blue, humpback, sperm and orca had all apparently increased between the second and third series. The author of that study remarked "any explanation for the lower minke abundance estimates also needs to explain why estimates for the other species increased." Since we would expect and hope that the species no longer being hunted would begin to recover from depletions one "explanation" is that such increase has in fact occurred.

[43] Pauly D., Trites, A. W., Capuli, E. and Christensen, V. (1998). "Diet composition and trophic levels of marine mammals" *ICES J. Mar. Sci*. **55**: 467-81.

[44] There is a curious anomaly in the S & V paper that seems to explain Tamura & Ohsumi's differing value. In their Table 2 they list the *assumed* spectra, with rounded values, and it is those that Tamura & Ohsumi have used. But S & V actually used different values in calculating their tables of food consumption.

[45] S. Ohsumi and other Japanese government scientists have long advocated unsustainable exploitation of abundant stocks such as minke whales, supposedly to reduce them to a notional Maximum Sustainable Yield level; not to do so, they argue, is "wasteful". Even *biologically sustainable* but precautionary non-zero catch limits that might be awarded under the RMP are in most cases unlikely to be *economically sustainable*, especially when hunted by pelagic expeditions thousands of miles from base: hence the need for subsidy by, for example, government support of "scientific whaling". A telling example is given by minkes in the Northeast Atlantic. When Norway decided to continue commercial pelagic minke whaling after its "objection" to the moratorium decision, the Government (of "Green" Prime Minister Gro Harlem Bruntland) announced that in doing so it would set catch limits according to the RMP. However, since then it has repeatedly "retuned" the RMP as originally adopted by the IWC, and otherwise "massaged" it, in such a way as to increase the risk of unintended stock depletion, in order to provide the higher immediate catch limits demanded by its

whalers and politically supported by its senior scientists. To justify the most recent planned expansion Norway has adopted the Japanese argument that the minke whales are eating too much fish. The sequence of steps in that process has been admirably described by Papastavrou and Cooke in their paper referenced in Note 9. Having, for technical reasons, reached the end of the line in "tweaking" the RMP, Norway is now proposing that the IWC revise and renegotiate it.

[46] This is examined in detail in the *Primary* document.

[47] Thanks for this reminder to Mario Livio, author of "The Golden Ratio: The Story of Phi, the Extraordinary Number of Nature, Art and Beauty". Headline Book Publishing, 2002, 2003, 294pp.

[48] S. J. Holt, (2007, in press) "Japan's Contribution to the Loss of Whales: A Historical Analysis of Japan's policy and of its Strategy and tactics in Pursuit of that Policy" 199pp, IFAW.

[49] Practice ***v.*** 1. To perform habitually, 2. To carry out an action.