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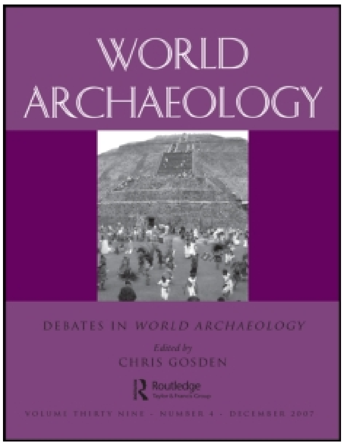

World Archaeology
Publication details, including instructions for authors and subscription information:
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Online publication date: 07 December 2009

To cite this Article Zangrando, Atilio Francisco(2009) 'Is fishing intensification a direct route to hunter-gatherer complexity? A case study from the Beagle Channel region (Tierra del Fuego, southern South America)', World Archaeology, 41: 4, 589 — 608

To link to this Article: DOI: 10.1080/00438240903363848

URL: http://dx.doi.org/10.1080/00438240903363848

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Is fishing intensification a direct route to hunter-gatherer complexity? A case study from the Beagle Channel region (Tierra del Fuego, southern South America)

Atilio Francisco Zangrando

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Abstract

This paper presents a case study of fish intensification in the subsistence of hunter-gatherers and fishers who inhabited the Beagle Channel region in southern South America. The main goal is to identify and to understand the multiple factors and conditions under which fishing intensification operated in this area, regarding it as a process integrated by multiple potential strategies. Ichthyoarchaeological assemblages from eight sites are examined against the predictions of a general intensification model evaluating variations in animal-based subsistence through time. Spatial, environmental and historical dimensions of the intensification process are analysed and evidence of increased effort in fishing activities is observed. Results support the existence of a foraging reorganization on a regional scale, a mechanism by which fish productivity was raised.

Keywords

Intensification; fishing; hunter-gatherers and fishers; zooarchaeology; Tierra del Fuego; subsistence.

Introduction

Intensification is one of the most relevant arguments considered by many archaeologists in understanding the emergence of non-egalitarian socio-political organizations in human populations. Some authors assume that, under conditions of stress, the redistribution of resources by increased storage and technological efficiency generates socio-economic inequalities (Ames 1985; but see Ames 1994, 2005). For others, hierarchy is not necessarily the result of population-resource imbalances or subsistence stress, but is the natural

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World Archaeology Vol. 41(4): 589–608 *Debates in World Archaeology*
© 2009 Taylor & Francis ISSN 0043-8243 print/1470-1375 online
DOI: 10.1080/00438240903363848

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product of the intensification of production and resource storage (Testart 1982; Woodburn 1982). From Marxist perspectives, intensification accelerates an already expected process of socio-economic change towards inequality (Bender 1985; Lourandos 1985). In summary, an important part of the disciplinary effort regarding intensification has focused on its effects and has supposed that it always leads to complexity.

Complex hunter-gatherers make up non-egalitarian societies, and ethnographically they are characterized by high population densities, large resident group sizes, sedentism, territoriality, food storage and focal exploitation of a particular resource (commonly fish) (Bailey and Milner 2002; Keeley 1988; Kelly 1995; Watanabe 1983). This ethnographic model is usually considered by archaeologists as the unique, direct consequence of intensification. In spite of the fact that there are very few ethnographic examples that correspond to this definition of complex hunter-gatherers (Kelly 1995), it is striking that archaeologists constantly claim to discover evidence of prehistoric non-egalitarian hunter-gatherers in many settings in the world.

Nevertheless, other authors have pointed out that intensification should not be seen as a strictly uni-directional process (Morrison 1994: 115), progressing from ‘simple stages’ to ‘complex stages’ in economic and social patterns (Rowley-Conwy 2001: 56–8): the effects of increasing populations, competition and social complexity may vary from case to case and they are not necessarily open to generalization.

Taking into account that the long-term study of fish use has been a central topic concerning intensification processes (Ames 1994: 216; Butler and Campbell 2004; Kelly 1995), the main aim of this paper is to address this discussion by investigating the relationship between fish exploitation, intensification of fishing practices and socio-economic patterns through the archaeological sequence of the Fuegian archipelago in southern South America. This analysis aims to understand intensification as a process and to appreciate the importance of context and historical contingency under which intensification operated in the Fuegian archipelago. In particular, it aims to avoid the assumption that complexity is an automatic outcome of such a process.

The paper is based on a series of zooarchaeological samples from eight sites located on the coasts of the Beagle Channel, which span 6400 years BP to the present (for a general context, see Orquera and Piana 1999a). This information is examined against the predictions of a general model evaluating changes in animal-based subsistence over time and relative representations of different fish taxa. Following that discussion, consequences for hunter-gatherer organizational strategies are analysed.

Conceptual approach to intensification

Intensification refers to the process by which human groups obtain more resources in a given unit of time or space in relation to an earlier period (Boserup 1965: 43–4; see also Binford 2001: 188; Morrison 1994: 115). During the last two decades many scholars have considered the increase of the procurement of fish – through cultural mechanisms that increased foraging efficiency – as the crucial factor leading to economic changes and social complexity (e.g. Ames 1985; Fitzhugh 2003; Hayden 1992). In fact, many of the debates about intensification have focused on the role and importance of fish, particularly of

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salmon in the Pacific Northwest. Others such as Ames (1994: 216) regard salmon as a crucial resource, but not the only one whose intensification was important in driving economic and social changes (1994: 218). These approaches emphasize the increased labour related to storage and capture as indicative of intensification.

More recent discussions concerning intensification have focused on faunal remains, and taken an alternative view, suggesting that intensification occurred through a declining foraging efficiency, which is theoretically consistent with the application of optimal foraging models in archaeology (e.g. Broughton 1997; Butler 2000; Nagaoka 2002). This theoretical perspective suggests that humans increased the use of lower-ranked resources as population density grew and as higher-ranked resource abundance declined (resource depression).

While it could be suggested that a semantic difference exists between these conceptual approaches to intensification (intensification as an increase in foraging efficiency vs. intensification as a decrease in foraging efficiency; see Butler and Campbell (2004)), they cannot be considered as mutually exclusive in a long-term process. This dual focus reflects archaeological biases in the debated issues of causes and consequences rather than the process itself (Morrison 1994: 115, 2003: 235). Though it is expected that these intensification factors (an increase in foraging efficiency and a decrease in foraging efficiency) may not occur simultaneously in an archaeological scale, they could be manifested successively in an intensification process.

Figure 1 presents a multi-level model for the interactive variables of an intensification process, which is also based on Morrison's (1994: 142–4) useful theoretical method. This broad view leads to the analysis of two 'component strategies' related to labour investment as possible mechanisms for intensification: specialization and diversification. As has been recently shown by many authors, these strategies are archaeologically detectable and they can be evaluated through the zooarchaeological record.

Labor investment involves increased effort and/or capital inputs in the use of a plot of land or sea (Morrison 1994: 142). If production efficiency increases, the cost of technological production and/or of logistical organization also has to increase. Specialization in craft production is commonly viewed as promoting efficiency in harvesting activities. Under these circumstances, subsistence strategies tend to be focused on a narrow range of species, which could be spatially and temporally concentrated in the landscape. For this reason, this strategy is usually associated with an increase and dominance in the representation of those species in the zooarchaeological record (Grayson and Delpech 1998; 2002; Grayson et al. 2001).

If technology remains stable in an intensification process, then any increase in production requires more labour input. An alternative strategy for 'major expansion in output from subsistence economy would have to come from diversification' (Earle 1980: 20, see also Binford 2001; Morrison 1994). This strategy relies on an increase in the diversity of foraging activities, and it could be based on animal resources spatially and temporally dispersed in the landscape. Morrison has proposed for intensification that diversification may 'involve the addition or elaboration of productive strategies that seem to be extensive rather than intensive of land or labour' (1994: 144). In sum, a diversification strategy would be displayed through the zooarchaeological evidence by an increase in the number of exploited species and/or by an increase of the relative abundance of the different species.

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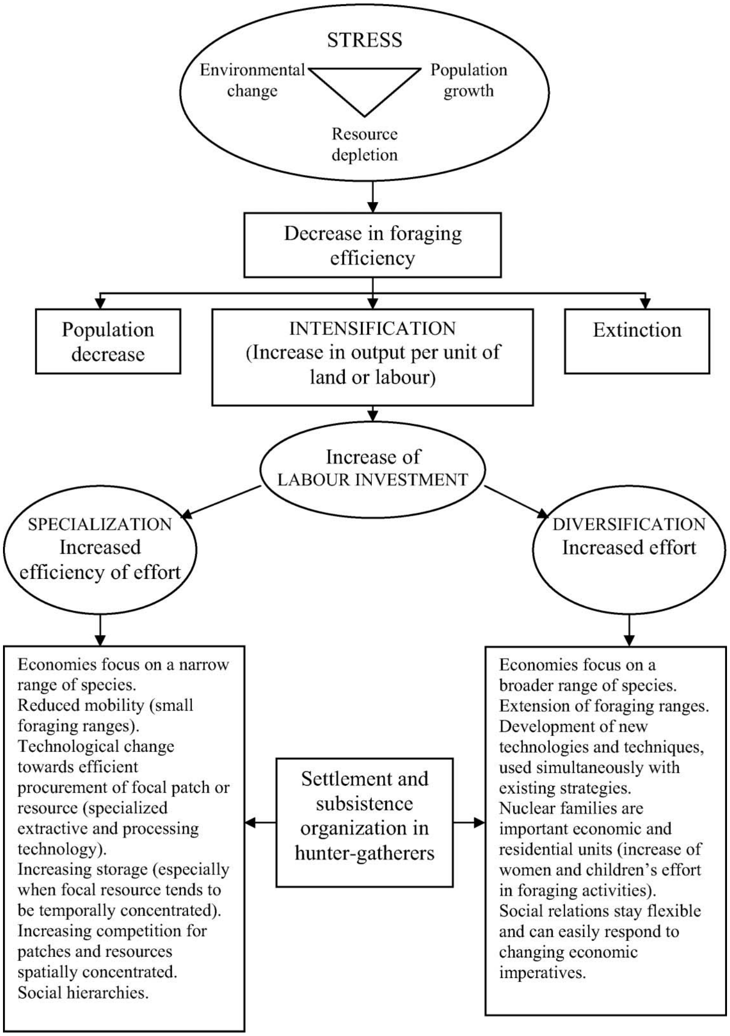

Figure 1 A multi-level model for the interactive variables of an intensification process.

An increase in labour investment is linked directly with both specialization and diversification processes, and it would be manifested by alternative developments in technological and/or procurement strategies (Betts and Friesen 2004: 359; see also Morrison 1994: 142–3). If production increases can take alternative pathways in intensification, we could also expect different socio-economic trends towards the exploitation and management of resources in hunter-gatherer societies (Fig. 1). On the one hand, specialization may be associated with the adoption of new technologies necessary for increasing efficiency in the procurement of a focal resource. Also, when subsistence becomes more focalized, competition for more productive niches increases and the resources become more defined. In these circumstances, hierarchies are necessary to resolve disputes and/or to redistribute resources under conditions of stress (Ames 1985; Fitzhugh 2003; Kelly 1995).

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On the other hand, existing technologies can continue to be used in the diversification strategy, but productivity could be increased by changes in logistic organization, exploiting new patches and/or expanding the spatial scope of foraging activities. The increase of productivity and diversity of procurement activities could also be promoted by changes in social roles, including hierarchies and gender, for example increased efforts in foraging activities by women and children (Lupo and Schmitt 2005). In sum, in both strategies – specialization and diversification – new forms of labour organization in animal procurement are required, but with differences in the potential consequences for socio-economic organization in hunter-gatherer populations.

Native fishing in the Beagle Channel region: fish resources and cultural background

From an ecological point of view, fish resources of the Beagle Channel region (see Fig. 2 below) can be divided into two main categories: littoral and pelagic. The first group is dominated by species of the Nototheniidae family, in which small-sized species predominate (Lloris and Rucabado 1991). They are detritivore and small crustacean feeders, inhabiting the *Macrocystis pyrifera* 'kelp belt' which runs along the entire length of the channel close to the coast (Moreno and Jara 1984: 105–6). These species can be caught among rocks on the beaches all year round. On the other hand, pelagic fish (e.g. hake – *Macruronus magellanicus*, *Merlucciius hubbsi*; sardines – *Sprattus fueguensis*; barracoutas – *Thysites atun*) present a greater diversity than the coastal families and only occasionally reach the shores. Some species of this group enter the Beagle Channel between December and April, and frequently end up beached in large numbers. Nevertheless, the predictability of these fish is lower than that of the littoral fish species

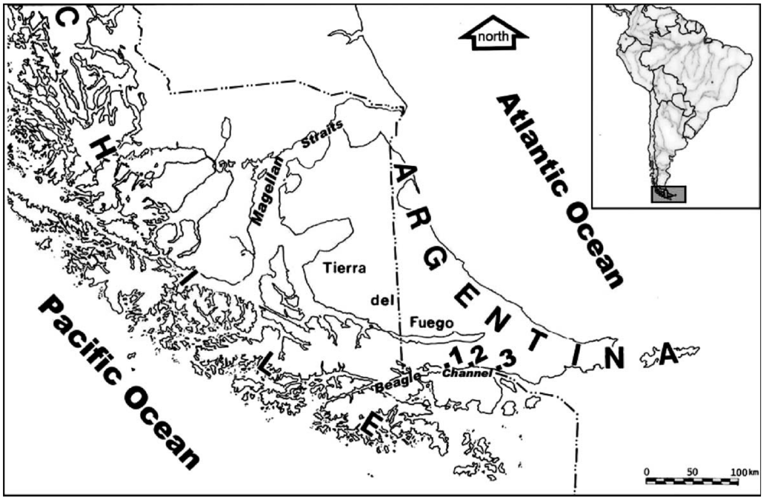

Figure 2 Tierra del Fuego, Southern South America. Archaeological sites: 1. Lancha Packewaia, Túnel I and Túnel VII; 2. Shamakush I, Shamakush X and Mischiuen 1; 3. Imiwaia I and Lanashuaia.

of the Beagle Channel, because the productivity of the shoals and the frequency of their being beached vary from one year to the next.

The exploitation of fish is evidenced throughout the archaeological sequence of the Beagle Channel region, starting approximately 6400 years BP (Orquera and Piana 1999a: 89). Nevertheless, while lithic and bone tools are abundant and varied, the artefacts that denote functional adjustment to fishing activities are scarce through the entire sequence. The only documented technologies are multi-barbed harpoon heads (which may have been used for fishing individual specimens) and pebbles with pecked grooves that could have been used as line weights.

From at least the sixteenth century, the Beagle Channel region was inhabited by a native society/group named Yamana. Most of the written sources agree that the Yamana included fish in their diet and were assiduous fishermen (Fitz-Roy 1839: 440; Hyades 1885: 515; Lothrop 1928: 32; see compilation in Orquera and Piana 1999b: 152–62). According to the chronicles, fishing activities were more frequent in shallow sea waters. These written sources point out that it was the women who took charge of this activity (Orquera and Piana 1999b: 156; Fiore and Zangrando 2006: 386). The women fished in the kelp belt using seaweed or tendon lines and small bait; thus they were able to catch large number of fish. These fishing lines had no fishhooks. Texts also described the use of harpoons for offshore fishing, mainly of predator fish (e.g. hake) (Gusinde 1986 [1937]: 534; Lothrop 1928: 150). In the ethnographic sources references are made to the beaching of sardines, but fishing baskets were also used in offshore patches to capture this resource (Gusinde 1986 [1937]: 533–4).

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Long-term variations in marine fishing: the zooarchaeological view

The fishbone assemblages discussed in this paper come from eight sites excavated at three different archaeological localities along the Beagle Channel; all of them are shell middens (Fig. 2). The materials were recovered by screening the excavated sediments through 5 and 2mm mesh screens. The NISP (number of identified specimens) was used to determine the significance of each of the fish taxa. Due to the fact that the excavated volumes are quite different between sites, the comparisons of abundance of identified fish remains were standardized by calculating the numbers of identified bones per cubic metre of sample matrix. Additional analysis of fish remains comes from samples (Orquera and Piana 2000: 254–9), which have approximate volumes of 4000cm^3 (1.056 gallon). They were taken from different stratigraphic components, so they can be associated with radiocarbon dates that had been determined on the basis of previous excavations (Table 1).

The fish remains represent a total of eleven species belonging to eight families. The ichthyoarchaeological samples were in a good state of preservation. Almost all the bone elements of the different species are represented, which facilitated their taxonomic identification. Previous taphonomic studies on fish remains indicate that there is no correlation between bone density of each bone and its respective MAU (marine amphibious unit) percentage in assemblages with diverse chronologies (Zangrando 2003: 89, 105; Fiore and Zangrando 2006: 379). This lack of a relationship between them suggests that there was no significant bone loss through time. Bone fragmentation was also

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Table 1 NISP frequencies for the fishbone assemblages

Archaeological localities	*Sites/assemblages*	*Radiocarbon years (BP)*	*Excavation samples (NISP)*	*Column samples (NISP)*	*Sub-unit samples (NISP)*	*Totals*
	Túnel I (Second Component)	6200 ± 100/4590 ± 130	13,794	1,286	1,484	16,564
	Lancha Packewaia (layer X)	4020 ± 70		2		2
	Túnel I (Fourth Component)	3530 ± 90/2660 ± 100	59			59
Túnel	Lancha Packewaia (layer D)	1590 ± 50/470 ± 50		444		444
Lancha Packewaia	Túnel I (Sixth Component)	670 ± 80/450 ± 60	387			387
	Lancha Packewaia (layer B)	280 ± 85		2,277		2,277
	Túnel VII	100 ± 45		2,659		2,659
Shamakush	Mischiúen I (layer F)	4890 ± 210	721	12		733
Mischiúen	Shamakush I	1020 ± 100/940 ± 110	3,997	659	811	5,467
	Shamakush X	500 ± 100	475	38		513
	Imiwaia (layers K-M)	6390 ± 50/5872 ± 147	4,001	4,713	3,077	11,791
Imiwaia	Imiwaia (layer B)	150 ± 70	6,658		492	7,150
	Lanashuaia[1]	‘modern’	1,442			1,442

Note
[1] After Piana et al. (2000).

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analysed. The results show high survival values in all assemblages, and there are no significant differences between species and assemblages with diverse chronologies (Zangrando 2007: 18–19).

Throughout the archaeological sequence, spatial and temporal variability in fish use was detected (Zangrando 2003: 112–14, 2007: 20–1). Sites located on coasts with hard-bottomed substrates show a predominance of nototheniids species, while on coasts with soft-bottomed substrates nototheniid remains are less abundant and sardines are highly represented. The relative abundance of pelagic fish varies between the different archaeological sites. The relative frequencies at Túnel I, Mischiuen I and Imiwaia I sites show spatial variability in the intensity of fish exploitation around 6400–4000 BP. The relative abundance in these sites shows that the frequency of fish bone remains in the lower shell middens of Imiwaia I is much higher than those in the contemporaneous layer D of Túnel I site and layer F of Mischiuen I. It was also noted that in Imiwaia I hake and sardines were the most consumed species, which suggests that the importance of ichthyofauna resources in human diet was higher during the summer (Zangrando 2003: 116–17).

The higher concentrations of coastal and pelagic ichthyofauna remains are found in the past 500 years of the archaeological sequence (Figs 3 and 4). Littoral fish revealed the strongest contrast between the frequency of fish remains in recent sites and earlier archaeological assemblages. The relative abundance of pelagic fish also increases significantly at recent archaeological sites and, moreover, qualitative changes can be observed through time. In this sense, hake and sardines are more abundant in earlier fishbone assemblages, while the recent assemblages are largely dominated by barracouta (*Thyrsites atun*).

In sum, the available information indicates that the relationship between fish and prehistoric Fuegian foraging practices varied in intensity and qualitatively both

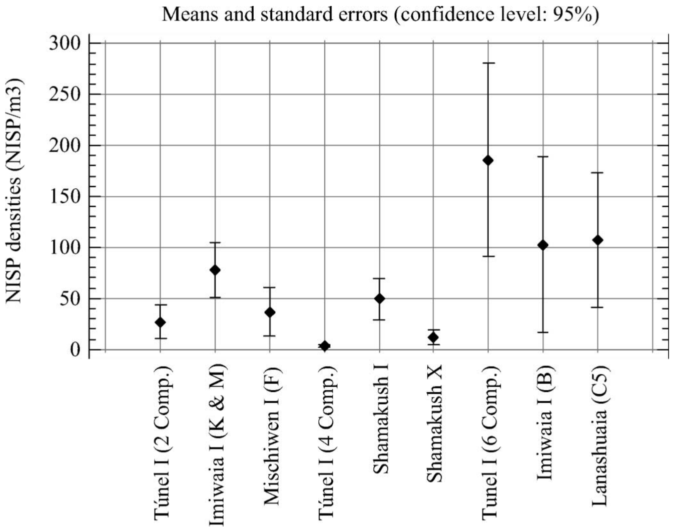

Figure 3 Fish remains representations in excavation samples.

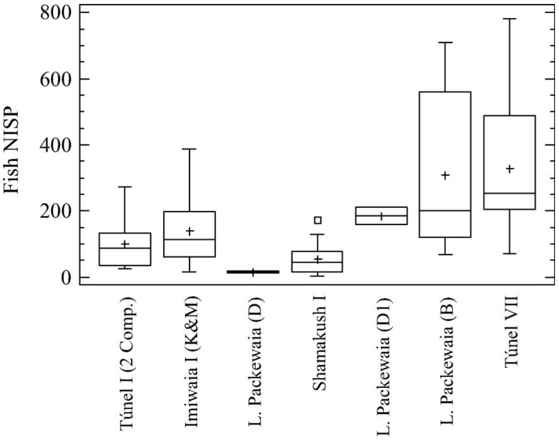

Figure 4 Fish remains representations in column and sub-unit samples.

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geographically and temporally. These data clearly document a substantial change in fish resource use, which set a first stage for more specific measures of archaeofaunal variability.

Identifying fish intensification: temporal changes and spatial dimensions in fishing practices

In recent years, specialization has been an important issue in zooarchaeological studies (Grayson and Delpech 1998, 2002; Grayson et al. 2001), and this concept was the focal point in the definition of intensification (e.g. Butler and Campbell 2004). In this paper, specialization is considered as a possible strategy of intensification. In this respect, due to the fact that specialized hunter-gatherers generally exhibit a reduction in economic diversity, we would hypothetically expect an increase in taxonomic dominance (not just abundance) in recent ichthyoarchaeological assemblages of Beagle Channel region and a reduction in other (non-fish) taxa.

To evaluate this expectation I calculated evenness indexes to show the dominance of a narrow variety of resources. This index can be calculated from Shannon's equitability function, where $V' = H'/\log_e S$ (Reitz and Wing 1999: 235; Grayson et al. 2001: 117). I defined *S* as the number of non-overlapping taxa, and *H*' is calculated as $-\sum [pi] [\ln pi]$ where p*i* is the proportion of each taxon in the identified sample (Grayson 1984: 159). Evenness values close to one reflect an even abundance across all taxa, while values close to zero reflect an assemblage dominated by only one species. Nevertheless, these measures provide little information on the relative abundance of fish among the assemblages they are comparing; therefore these must be examined against the entire taxonomic compositions to explore the nature of the specialization (or generalization) (Broughton 1994, 1997). For this reason, I also calculated the abundance of fish is with the following function: $\sum$ NISPfish/ $\sum$ NISPpinniped + NISPguanaco + NISPfish. This procedure provides an index that ranges between 0 (absence) and 1 (complete dominance). In this calculation three faunal categories were used: fish, pinniped (fin-footed mammals, including the *Otariidae* family – eared seals, including sea lions) and guanacos (*Lama guanicoe* – camelids).

The use of these variables was defined in agreement with the prey choice model, which relies on the assumption that predators seek all prey types simultaneously in a relatively homogeneous environment, and that the most efficient strategy is to take the highest-ranked prey according to its potential dietary yield (Broughton 1994: 502–3). Following these assumptions, the inclusion of fish in the subsistence strategy depends on the encounter rate with the highest-ranked prey, represented in the Beagle Channel region by pinnipeds and guanacos.

One potential problem with this reasoning is that small-bodied prey types could be taken by mass harvesting and their overall rate could be higher than individual catches of larger prey types (Madsen and Schmitt 1998: 453; Zangrando 2003: 74; Ugan 2005: 84). However, there is no evidence of mass harvesting technologies (such as fishing nets) in the archaeological record of Beagle Channel region, which provisionally argues against the use of such technologies in the past.

The plot of evenness values demonstrates a moderate variation throughout the system (Fig. 5): at the beginnings of the regional sequence with values varying between 0.28 and 0.38, while after 4500 years BP the values oscillate between 0.58 and 0.87. The lower evenness values observed in the first stages of the sequence could be explained by a major abundance of bone remains of pinnipeds in early assemblages (see NISP values in Appendix A). Nevertheless, the moderate evenness and lack of marked diachronic change after 4500 years BP appear to be a result of the lack of dominance of any taxonomic group in the assemblage in the later part of the archeological sequence.

Figure 6 presents a plot of fish and mammal indices through the archaeological sequence. This graph shows the diachronic distribution of index values of key taxonomic groups, which were calculated with the same database used in the previous analysis. This long-term distribution demonstrates that the representation of key resources varies in relatively high proportions through the archaeological sequence. Between 6000 and 1000 years BP, the faunal assemblages are dominated by guanacos and pinnipeds, while in the

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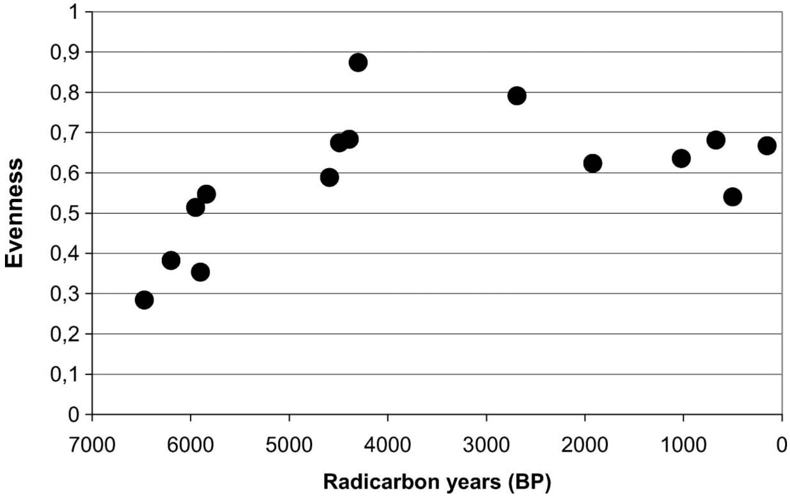

Figure 5 Plot of evenness values across Beagle Channel sequence.

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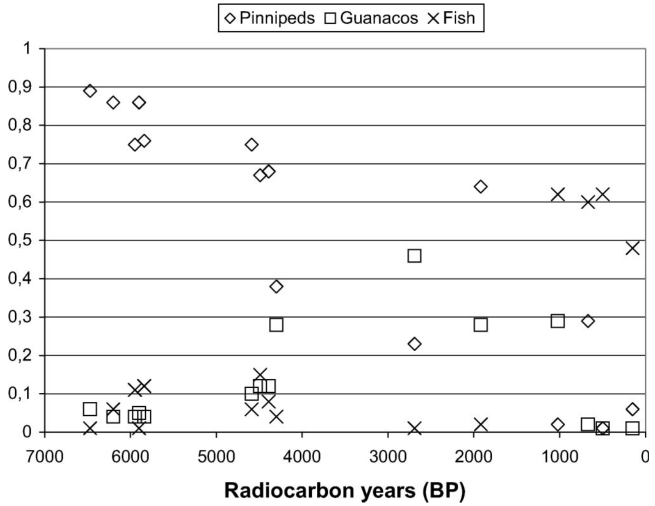

Figure 6 Plot of fish and mammal indices across the Beagle Channel sequence.

last 1000 years fish clearly contribute with higher numbers of identified specimens. In sum, although fish specialization does not appear to increase through time, there is a significant increase of fish representation in late assemblages of the region, which could be related to depression of larger prey types within coastal and inland patches. Nevertheless, it is necessary to consider additional lines of information, like changes in demographic structure (i.e. decline in body size and age of sea lions) to evaluate this hypothesis.

Although the hunter-gatherer societies of the Beagle Channel did not become specialized fishers through time, the increase in fish representation must have involved more labour input in fishing activities. As was previously noted, an alternative strategy for increased output in a hunter-gatherer economy would have to come from diversification (Earle 1980: 20; Morrison 1994: 144).

The diversification in fishing activities was measured through Shannon's diversity function (H' = [p*i*] [ln p*i*]; Grayson 1984: 159), which takes both the total number of species and the relative proportion of each species into account (diversity). The archaeological samples, and not the excavation samples, were used in this analysis for two reasons:

1 there is a known relationship between sample size and diversity or richness (Grayson 1984: 158–67); and
2 there are important size differences of excavated surfaces between sites (these differences are significantly reduced among the samples).

For a closer inspection of this factor, I correlated the Shannon index with its respective sample size for each assemblage. No significant correlation was found ($r^2 = 0.29$ $p \geq 0.10$), which suggests that diversity indexes are not affected by sample size (Fig. 7).

Davidson (1981: 17–33; see also Bailey and Davidson 1983) advised that in many cases variations in faunal representations may have resulted from short-term 'tactical changes' caused by differential seasonal availability of resources rather than intensification ('strategic changes'); however, this is not the case observed here. Figure 8 presents a simplified distribution of fishing diversity values, indicating a clear increase over time in the diversity of fish resources. This diversification occurred at least during the last 1000 years BP, which also coincided with the increase of fish frequencies. This pattern invites us to explore this variation in more detail in the context of the concept of labour investment.

Labour investment is usually manifested by the adoption of new fishing strategies or technologies. Although this factor can be evaluated through different kinds of evidence, I will explore the potential development of new strategies by the analysis of the icthyoarchaeological record. The distribution of the species present in the archaeological

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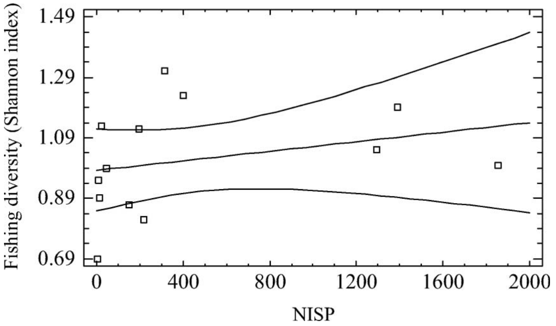

Figure 7 Plot of fish diversity (Shannon Function) against sample size (NISP).

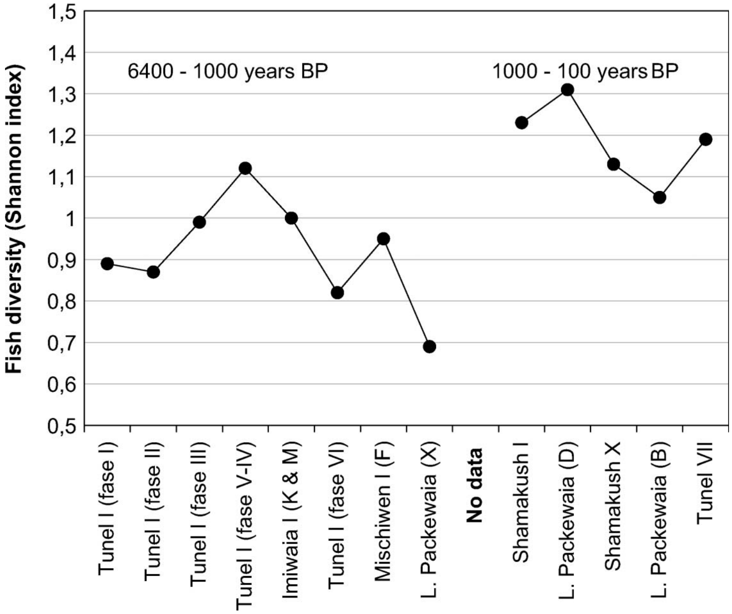

Figure 8 Plot of fish diversity (Shannon Function) of two sections of the Beagle Channel sequence (core and column samples).

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sequence, the knowledge of the habitats of these fish and the estimation of individual sizes can be used together to hypothesize the strategies by which fish were captured (Wheeler and Jones 1989).

A significant increase in diversity implies the addition of new fish species, as occurred in the Beagle Channel region with the barracouta (*Thyrsites atun*). While other pelagic fish appear throughout the sequence with some variations, the barracouta appears as an important pelagic taxon only during the last 1000 years (Fig. 9). It does not seem probable that changes in environmental conditions could have introduced *Thyrsites atun* to the Beagle Channel ecosystem in later times. Large numbers of this taxon are present in assemblages contemporaneous both with the Medieval Climate Optimum (*c*. 1000 years BP) and the Little Ice Age (*c*. 200 years BP). Both episodes were recorded in the Beagle Channel, and they represent the extreme variations of surface seawater temperature throughout the whole archaeological sequence (Obelic et al. 1997).

It is worth remarking that barracouta and other offshore species have different spatial distributions. In fact, hake and sardines can frequently be fished in close inshore waters and occasionally end up beached in large numbers, while only young individual barracouta can be caught near the shores. As supported by biological research in Fuegian sea waters (Fenucci et al. 1974) and in other regions of the southern hemisphere (Griffiths 2002; Leach et al. 1999), old specimens of *Thyrsites atun* can be caught only in offshore waters far from the coasts.

The analyses presented so far indicate an increase in both quantitative output and diversity in fishing activities, especially through the exploitation of *Thyrsites atun*. Though labour investment can be manifested in different ways, I will explore the adoption of new harvesting strategies as they relate to the increase of labour input. To evaluate changes in the foraging patterns of prehistoric fishers, I estimated live fork length from bone

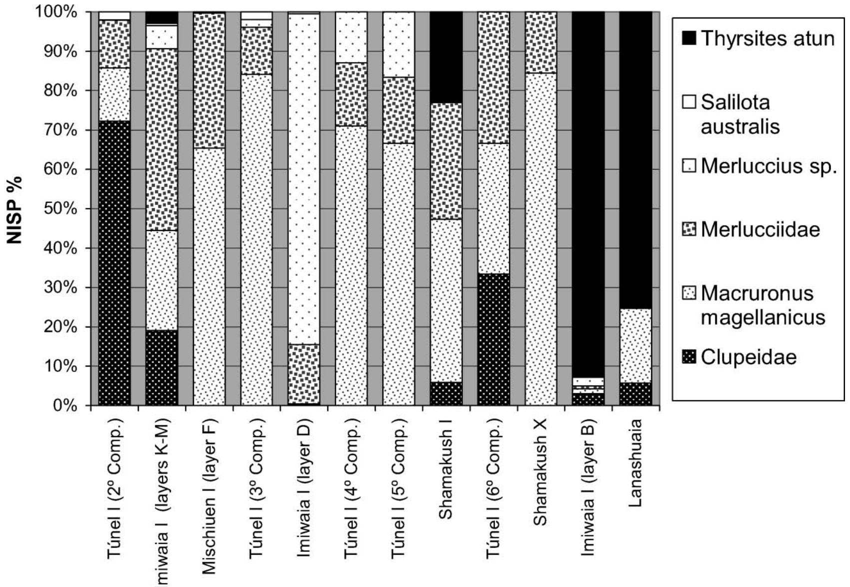

Figure 9 Pelagic fish representations (NISP%) across the Beagle Channel sequence.

measurements of *Thyrsites atun* archaeological remains using the regression constants published by Leach et al. (1996: 22). With this analysis I established a size-frequency diagram of the archaeological fish catches. The frequency curve is close to a normal distribution with individuals ranging in size from 620 to 720mm (Fig. 10). This was compared with modern research trawl data for barracouta (Leach et al. 1999: 16): it is immediately apparent that the archaeological fish catches in Beagle Channel are dominated by large specimens and do not contain younger age categories (up to 600mm approximately). Thus, it appears that by 1000 years BP fishing activities in the Beagle channel had expanded to include a significant use of the offshore patch, and consequently involved new strategies of fish procurement.

In conclusion, the analyses presented above indicate that diversity increased throughout the sequence and the adoption of strategies of offshore fishing has been detected. In other words, not only is there a considerable increase in fish remains frequencies during the last 1000 years BP, but there were also at least two identified indicators of an intensification process: diversity increase and new labour investment in offshore fishing.

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Discussion

What was the relationship between fish intensification and variations in social and economic spheres? From a comparative point of view, the hunter-gatherers and fishers that inhabited the Fuegian archipelago did not undergo the deep changes of socio-cultural complexity that took place with the intensive use of fish in other areas of the world. In the southern South American case, they have been characterized as highly mobile groups, and the ethnographic and archaeological data do not support the existence of semi-permanent dwellings, storage or any kind of formalized political leadership (Orquera and Piana 1999a: 118–19). Steager (1965: 75) attributed the lack of these factors and the low regional population density in comparison to the coastal hunter-gatherers of the north-west coast of America to a ‘deficiency’ in developing the complex technology required for offshore fishing. In spite of the fact that the relatively simple lifestyle of the littoral groups that

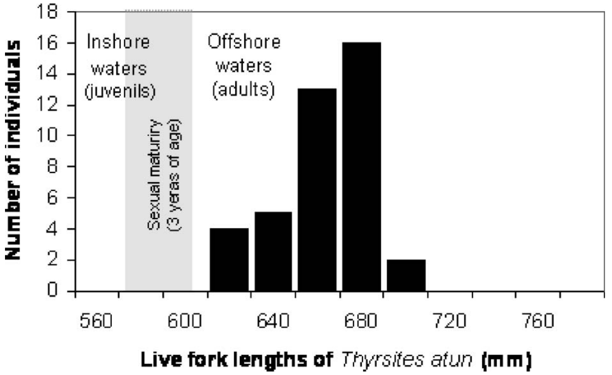

Figure 10 Live fork-length distribution of *Thyrsites atun* in fishbone assemblages of Beagle Channel region.

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inhabited the Fuegian archipelago is no longer viewed as a bad adaptive phenomenon, an interpretation of social and economic stability has persisted (Orquera and Piana 1999a: 97–109). It has been proposed that, based on similar technology through time, the hunter-gatherer-fisher societies did not surpass the carrying capacity of the local environment (Orquera 2005: 111–12). Of particular note is that the archaeological assemblages of the Beagle Channel region do not provide evidence of technology that could have increased the efficiency of fishing activities, like fishhooks or fishing nets. Nevertheless, as has been shown in this paper, the significant increase in the exploitation of fish resources in the later part of the archaeological sequence, together with the addition of a new category of pelagic fish resource, provides evidence for increased effort and suggests labour reorganization in fishing activities.

Though many factors have been proposed to account for particular cases of resource intensification (e.g. Ames 1994; Bender 1978; Broughton 1994; Cohen 1977; Morrison 1994; Yesner 1984), demographic increase is often seen as a requirement or even a motivating factor for this process. Moreover, in most models, the balance between population and resources, the distributional structure of resources and the periodicity in access to them are the determining factors in evaluating the hypothesized effects of increasing populations. It should be noted that the fishing-intensification strategy undertaken in the Fuegian archipelago, which clearly represents diversification, is quite different from the strategies carried out among hunter-gatherers and fishers in other areas. For example, the intensification process recognized by many authors for north-western North America is evidently a contrasting case. Though a recent zooarchaeological review found no evidence of an increase in salmon use relative to other resources (Butler and Campbell 2004: 389), this resource can be thought of as the most important in intensification of fish production in that region (Ames 2005: 99; Cannon 1992: 511–15). Specialized strategies for this focal resource (notwithstanding the fact that salmon are variable in intensity at both different locations and points in a year) could be essential to maintain high regional population levels and seem to be correlated with reduced mobility, storage and social concentration. As an evolutionary corollary, residential group size and permanence would increase, leading to ownership claims over resources and resource extraction locations, which would combine with territoriality and violence over competition for resources (see Fitzhugh 2003: 227–44).

As was pointed out, this possible understanding of intensification does not really apply to the trends observed through the archaeofaunal evidence of the Fuegian archipelago. If intensification is usually linked to an increase in population, then it is necessary to explore the nature of intensification in southern South America.

A recent study supports the view that the demographic densities of hunter-gatherers with a life system specialized in littoral and marine resources remained relatively stable through time (Orquera and Piana 2006: 27). However, this socioeconomic system was not isolated in the Fuegian environment and coexisted with populations of terrestrial and coastal hunter-gatherers, which inhabited the main island of Tierra del Fuego. It is possible that a more intensive use of the south-eastern coast of Tierra del Fuego by terrestrial hunter-gatherer groups could have resulted in an overall increase of population density in the Fuegian archipelago during the Late Holocene, increasing the exploitation of terrestrial and marine mammals in coastal locations. As we saw in Figure 6, a significant increase of fish remains representation occurred simultaneously with an important decrease in mammals during the last 1000 years in the archaeological sequence of the Beagle Channel region. Nevertheless, it is not possible to support a depression of the larger prey types, as an expression of instability between population and resources. Changes were not observed in demographic structure of resources: for example, body size and age of sea lions do not decline through time (Orquera and Piana 1993–4: 345; Schiavini 1993: 361), and the sizes of mollusks are essentially similar in earlier and later assemblages (Orquera and Piana 2001: 358). However, despite the fact that it is not possible to suggest a 'population pressure', the demographic increase generated by neighbouring populations combined with the local ones could have enhanced competition for resources and particular extraction locations between human groups with terrestrial and aquatic mobilities. In the Beagle Channel sequence, the faunal evidence supports the development of foraging variations on a regional scale, a mechanism by which fish productivity could be raised. Thus, the strategies that imply diversification, like the fishing activities in this case study, would have reduced the risks associated with a specialized strategy focused on a narrow range of resources in particular, and would therefore have promoted stability in the social and economic organization by an increase in the regional carrying capacities (Hayden 1981: 522–8; see also Binford 2001). This interpretation contrasts with the 'complex end results' that implicitly or explicitly appear in many models of intensification.

In conclusion, the analysis presented in this paper provides a case of fish intensification in one particular hunter-gatherer-fisher context and simultaneously demonstrates that hunter-gatherer and fisher societies can adopt different paths in this process. Moreover, this supports the idea that resource intensification should be viewed as a multi-dimensional process, where changes towards intensification are not necessarily straight paths towards social complexity.

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Acknowledgements

A preliminary version of this paper was presented at the 71st Annual Meeting of the Society for American Archaeology. I am very grateful to Luis Orquera, Angélica Tívoli, Dánae Fiore, Luis Borrero and four anonymous reviewers for their helpful comments and suggestions. I would like to thank Lucía Zangrando and Dánae Fiore for their assistance in improving my use of English in the paper.

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Appendix A: NISP of faunal assemblages used for the calculation of evenness index

Sites/Assemblages	*Radiocarbon dates*	*Pinnipeds*	*Guanacos*	*Birds*	*Fish*	*H'*	*V'*
Túnel I (Second Comp. layer D)							
Fase I	6470 ± 100/6020 ± 120	2223	149	70	39	395	284
Fase II	6410 ± 150	6645	305	252	463	530	382
Fase III	5950 ± 170	3288	191	185	484	713	514
Fase IV		11346	752	901	194	490	353
Fase V	5840 ± 185/5630 ± 120	5067	254	450	859	758	547
Fase VI	4590 ± 130	4764	642	515	387	815	588
Fase VII		4434	830	305	1028	934	674
Fase VIII		3398	618	527	404	947	683
Túnel I (Third component)	4300 ± 80	983	741	800	107	1212	874
Túnel I (Fourth component)	2690 ± 80/2660 ± 100	780	1521	960	44	1097	791
Túnel I (Fifth component)	1920 ± 80	707	318	64	19	864	623
Shamakush I	1020 ± 100/940 ± 110	102	1227	231	2605	881	635
Túnel I (Sixth component)	670 ± 80/450 ± 60	113	10	32	233	944	681
Shamakush X	500 ± 100	9	9	198	352	754	540
Imiwaia I (layer B)	150 ± 70	313	6	2156	2366	925	667