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ON SUBJECTIVITY IN THE JUDGING OF ACOUSTIC RECORDS; COMPARISON OF DEGREE OF HOMOGENITY IN ALLOCATION OF ECHO VALUES BY DIFFERENT TEAMS.

by

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ABSTRACT

On four fish abundance estimation surveys in the Barents sea, january-february 1993, the acoustic records were judged by two independent teams. We have analyzed the degree of homogenity in allocation of echo values to various species by the different teams.

In general the average echo value allocated to a species was rather similar, but significant and noticeable differences were detected. Studies of the allocation in a one-to-one and time scale revealed greater variations, but still a reasonable degree of similarity in judgement by the different teams. The reason for variation in allocation of echo values to various species among different teams are discussed.

INTRODUCTION

During the last two decades, there has been a substantial development of the echo integrator technique towards an accurate, empirical method for measuring the abundance of fish stocks. Technically, the performance of the instruments has improved the sensitivity for weak signals, and the tendency to saturation for strong signals has been overcome by the introduction of digitized echo sounders (*Bodholdt et al., 1988*). By use of standard spheres, the instruments can be reliably calibrated (*Foote et al., 1987*) so that the echo integrator output can be converted to absolute fish densities if the target strength (and length composition) of the fish is known. This is the case for many economically important clupeoid, gadoid and salmonid species. By use of split beam or dual beam transducers, the target strength of the fish may also be measured directly during surveys.

When conducting acoustic abundance estimation surveys of fish stocks, the recorded echo integrals (echo values) must be split on species and size groups. To make this scrutinizing process easier and more reliable, digitized, graphical post processing systems have been developed. (*Knudsen, 1990. Foote et al. 1991.*). To identify the echo recordings for species and size groups, it is necessary to conduct fishing by a gear that takes samples as representative as possible. For this purpose, it is common to use bottom or pelagic trawls. In principle, the partitioning of the echo values should be done according to the catch composition in the trawl samples (*Dalen and Nakken, 1983*). Sampling musttherefore be conducted regularly during surveys, and preferably also every time the pattern of the echo recordings (echogram) changes.

However, the representability of the sampling gear may be questionable due to different catch efficiencies between different species, but also length dependent changes in catch efficiency. (*Engås and Godø, 1989*). Some species, especially when schooling, may also perform strong avoidance reactions (*Midsund and Aglen, 1992*), and therefore be poorly represented in the catches. Therefore cases may often occure when it is <u>not</u> correct to allocate echo values strictly according to the catch composition. In such cases, the allocation of the echo values must be based on the operators knowledge and experience of what species and size groups the recorded echos correspond to (*Dalen and Nakken, 1983*). Such a procedure clearly introduces a subjective element into the echo integration method (*MacLennan and Simmonds, 1992*).

We have studied the degree of subjectivity in the judging of acoustic records by comparing the homogenity in allocation of echo values by two independent teams on four surveys in the Barents Sea in winter 1993.

Similar studies have beeen performed before. *Mathiesen et al., (1974.)* compared the visual interpretation between forur independent observer teams. The visual interpretation into fish, plankton and spurious signals showed a large amount of variability and they conludes: "It is evident that the variability can be reduced by training through comparative readings and interpretation; but this may only mean consistency which does not necessarily reflect accuracy."

MATERIALS AND METHODS

The data analyzed are from four fish abundance surveys in the Barents sea. More details on these surveys can be found in *Korsbrekke et al., (1993)*.

During these surveys the acoustic echograms were judged by two independent teams; both teams having access to catch information from trawl stations. The experience of the team members varied from the beginner stage to having conducted such work for more than twenty years. The teams were therefore set up such that at least one (of the two members in a team) had some experience in the field. A standard procedure was followed (*Dalen and Nakken, 1983. Foote et al. 1991*).

The four surveys are:

Survey	Ship	Start	Stop	Area	No of obs.
A	R/V G. O. Sars	12. january	29. january	North and Central	203 × 5 nm
B	R/V Johan Hjort	9. january	28. january	East and s. east	302 × 5 nm
C	R/V Johan Hjort	28. january	18. february	Central and s.east	289 × 5 nm
D	R/V Johan Hjort	18. february	25. february	Central and s.west	154 × 5 nm

The echo values were stored in a database as density indices for 5 nautical miles intervals and for the different species. In the analysis presented in this paper only data from periods with fairly good weather are used. In addition, recordings made when the ship was towing a trawl were also deleted. As seen from the table above, the remaining observations represent sailed distances of 1015, 1510, 1445 and 770 nautical miles.

The analysis made can be grouped in three:

1) Wilcoxon 2-sample test was used to test for differences in the median echo values. The sign rank test was used to look for trends or bias giving a positive (or negative) difference between echo values.

2) Means for each team, survey and species were calculated and visualized. In addition logged differences for the 4 most important species (highest means) of each survey and log of the total echo value were plotted on a time scale (e.g. ships log).

3) Correlations between the differences were estimated looking for possible "causes".

RESULTS

The means for each team, survey and species are given in table 1 and plotted on figure 1. There are large differences between the means for redfish in survey A, herring and polar cod in survey B, herring and capelin in survey C and cod and redfish in survey D. In figures 2-5 the logged differences are shown together with the logged total echo values. Only a part of each survey is shown. Blank periods represent trawl stations or bad weather conditions. The variability of the differences seems high when compared to the relatively low differences between the mean echo values. These figures also indicate that the relative differences (compared to the total echo value) decreases with increasing echo values.

As seen in table 1 the null hypothesis of equal medians between the teams was rejected at the 5% level in 10 out of 23 tests. Among the higher mean echo values we find capelin and herring in survey C, capelin in survey B and cod in survey D. Note that the significant result for capelin in survey B was despite of almost identical means. Table 1 also presents the results from the sign rank test on the pairwise differences. 13 out of 23 tests gave significant results at the 5% level.

The estimated correlation coefficients between differences were ranked after absolute value and are presented in table 2. Three of the correlations had an absolute value higher than 0.5. Capelin and redfish in survey A, with an estimated correlation of -0.72, capelin and polar cod in survey B, with an estimated correlation of -0.67, and capelin and herring in survey C, with an estimated correlation of -0.96.

DISCUSSION

The data analysis presented in this paper treats the data as stochastic variables. This is a reasonable (and necessary) approach when treating total echo values or fractions of the total echo value. The properties of these stochastic variables depend also on the survey design. But in addition one should keep in mind that the variation between teams is due to a subjective process involving individual decisions. One should therefore take care when drawing conclusions. See also *MacLennan and Simmonds (1992).*

We can more or less assume that typical effects in biomass estimation are mean effects from the allocation of echo values. That is: If the assumed length composition is relatively stable, a 10 % higher mean echo value gives a 10% higher biomass estimate. Therefore similar mean echo values are "nice" results.

Several interesting results should be pointed out. The result for capelin in survey B is "nice", but the tests indicate a skewed distribution of the differences. We can interpret this as follows: In most observations one team allocates slightly higher echo values to capelin than the other team. On the other hand this is compensated in a few observation where the second team allocates much higher echo values to capelin.

One other distinct result is the differences for capelin and herring in survey C. The very high negative correlation show what went "wrong". Team 2 allocated much higher echo values to herring whereas team 1 allocated more to capelin. The higher allocation to capelin was the most obvious, but the mean echo value for the other species was higher as well.

A third result is the connection between capelin and polar cod in survey B. When, as mentioned before, the second team was allocating high echo values to capelin, it seems that the first team was allocating higher echo values to polar cod.

We argue that the two most probable causes for different results are:

1) Different assumptions on trawl efficiency will lead to different results.

2) Experience may differ. Relative rapid changes in species composition compared to the densities of trawl stations makes high demands on skill and experience in "judging" echograms and identifying species from their echo traces.

Some possible factors that effected the trawl efficiency during these surveys are:

a) Depending on bottom conditions smaller fish may escape under the fishing line of the bottom sampling trawl (*Engås and Godø, 1989*).

b) Some demersal species (especially cod) swimming from 5 to maybe 50 meters above the bottom, can dive down to the bottom due to the presence of the vessel and/or the fishing gear thus effecting the catch efficiency of the bottom trawl.

c) As mentioned in the introduction, some species (especially herring) forming schools, may also perform strong avoidance reactions (*Midsund and Aglen, 1992*). This effects both the pelagic and the bottom sampling trawl.

d) The large pelagic sampling trawl could be effected by mesh selection in the opening of the trawl, giving lower catch efficiencies, depending on species and size, than expected from fish densities and swept volume.

We choose to conclude with the following: The method of abundance estimation with echo integrators requires skillfull operators when allocating echo values to different species. The pairwise comparisons of independent "judging" teams may be used to train new personell in the method, but also experienced observers could gain higher consistency. The method could be further improved through more knowledge on trawl efficiencies under a range of conditions and the implementation of this knowledge in the scrutinizing process.

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Table 1:

Survey	Species	N	$\overline{s_A}^{(1)}$	$\overline{s_A}^{(2)}$	Wilcoxon 2-Sample test		Sign Rank Test	
					Z	Prob > |Z|	Sign Rank	Prob > |S|
A	Cod	203	11.6	12.3	1.50092	0.1334	1535	0.0426
	Haddock		10.4	9.58	1.12716	0.2597	801	0.2164
	Herrring		0.09	0.31	-0.55267	0.5805	-72	0.0045
	Capelin		166.4	174.3	-1.71284	0.0867	-3088.5	0.0001
	Redfish		18.3	15.1	-1.34132	0.1798	-816	0.2906
	Polar cod		0.00	1.37	-4.07386	0.0001	-68	0.0001
B	Cod	302	19.8	22.1	-.786724	0.4314	-1604	0.2169
	Haddock		27.6	26.2	-1.29002	0.1970	41	0.9668
	Herrring		23.0	18.2	-2.68424	0.0073	-900	0.2545
	Capelin		68.3	68.2	-2.08822	0.0368	-860	0.0476
	Redfish		1.14	1.6	-1.95451	0.0506	-156.5	0.4346
	Polar cod		16.8	27.9	-2.32228	0.0202	-1339	0.0001
C	Cod	289	46.0	43.5	-.589900	0.5553	1825	0.1531
	Haddock		32.1	29.2	0.108373	0.9137	5666	0.0001
	Herrring		26.6	45.3	-5.30975	0.0001	-6497	0.0001
	Capelin		93.4	86.3	-2.14544	0.0319	-4022.5	0.0001
	Redfish		7.25	5.37	-1.05327	0.2922	11.5	0.9916
	Polar cod		18.6	16.7	0.692296	0.4888	124.5	0.0049
D	Cod	154	26.1	18.5	4.85730	0.0001	4390	0.0001
	Haddock		12.9	14.5	-0.83317	0.9336	13	0.9796
	Herrring		0.16	0.29	-2.32276	0.0202	-19	0.0488
	Capelin		0.39	0.04	5.93654	0.0001	375	0.0001
	Redfish		13.2	9.86	4.28223	0.0001	1882	0.0001
	Polar cod		0.00	0.00				

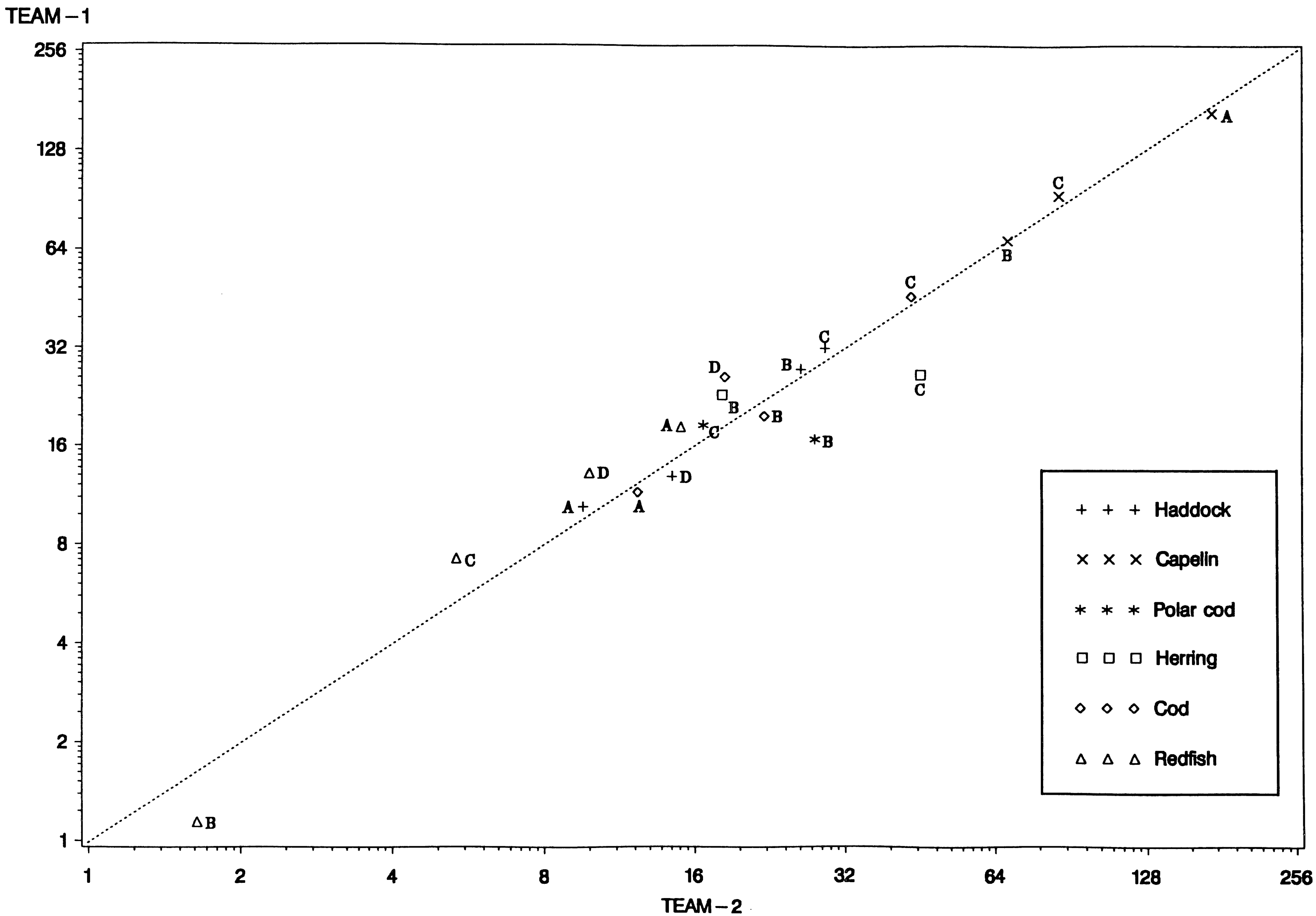
Table 2:

Survey	Species	Ranked Spearman Correlation Coefficients (Δs_A)				
A	Cod	Capelin -0.439	Polar cod 0.231	Redfish 0.209	Herring 0.105	Haddock -0.077
	Haddock	Capelin -0.288	Herring -0.240	Redfish 0.126	Cod -0.077	Polar cod 0.011
	Herring	Haddock -0.240	Cod 0.105	Redfish 0.079	Capelin -0.039	Polar cod -0.035
	Capelin	Redfish -0.719	Cod -0.439	Polar cod -0.425	Haddock -0.288	Herring -0.039
	Redfish	Capelin -0.719	Cod 0.209	Haddock 0.126	Herring 0.079	Polar cod 0.013
	Polar cod[1]	Capelin -0.425	Cod 0.231	Herring -0.035	Redfish 0.013	Haddock 0.011
B	Cod	Herring -0.398	Haddock -0.340	Polar cod 0.053	Redfish 0.021	Capelin 0.005
	Haddock	Redfish -0.444	Cod -0.340	Herring -0.225	Polar cod 0.022	Capelin 0.004
	Herring	Cod -0.398	Polar cod -0.345	Haddock -0.225	Capelin -0.054	Redfish -0.001
	Capelin	Polar cod -0.673	Herring -0.054	Cod 0.005	Haddock 0.004	Redfish -0.004
	Redfish	Haddock -0.444	Cod 0.021	Polar cod -0.009	Capelin -0.004	Herring -0.001
	Polar cod	Capelin -0.673	Herring -0.345	Cod 0.053	Haddock 0.022	Redfish -0.009

Table 2:

Survey	Species	Ranked Spearman Correlation Coefficients (Δs_A)				
C	Cod	Herring -0.198	Polar cod -0.183	Haddock 0.146	Redfish -0.132	Capelin 0.049
	Haddock	Cod 0.146	Polar cod -0.131	Herring -0.062	Capelin -0.054	Redfish -0.031
	Herring	Capelin -0.958	Cod -0.198	Haddock -0.062	Redfish -0.019	Polar cod -0.007
	Capelin	Herring -0.959	Haddock -0.054	Cod 0.049	Redfish -0.021	Polar cod -0.015
	Redfish	Cod -0.132	Polar cod 0.096	Haddock -0.031	Capelin -0.021	Herring -0.019
	Polar cod	Cod -0.183	Haddock -0.131	Redfish 0.096	Capelin -0.015	Herring -0.007
D	Cod	Haddock -0.264	Capelin -0.103	Herring -0.031	Redfish -0.008	
	Haddock	Redfish -0.344	Cod -0.264	Herring 0.206	Capelin 0.061	
	Herring	Redfish -0.339	Haddock 0.206	Cod -0.031	Capelin 0.022	
	Capelin	Redfish -0.136	Cod -0.103	Haddock 0.061	Herring 0.022	
	Redfish	Haddock -0.344	Herring -0.339	Capelin -0.136	Cod -0.008	
	Polar cod[2]					

1. In survey A only team 2 did allocate any echo values to Polar cod. Team 1 allocated the value 0 to polar cod.
2. None of the teams in survey D allocated any other echo value than 0 to Polar cod.



Mean values of echo distribution for the different species and surveys

Figure 1

Figure 2

Differences between team-1 and team-2. A (typical) part of survey A.

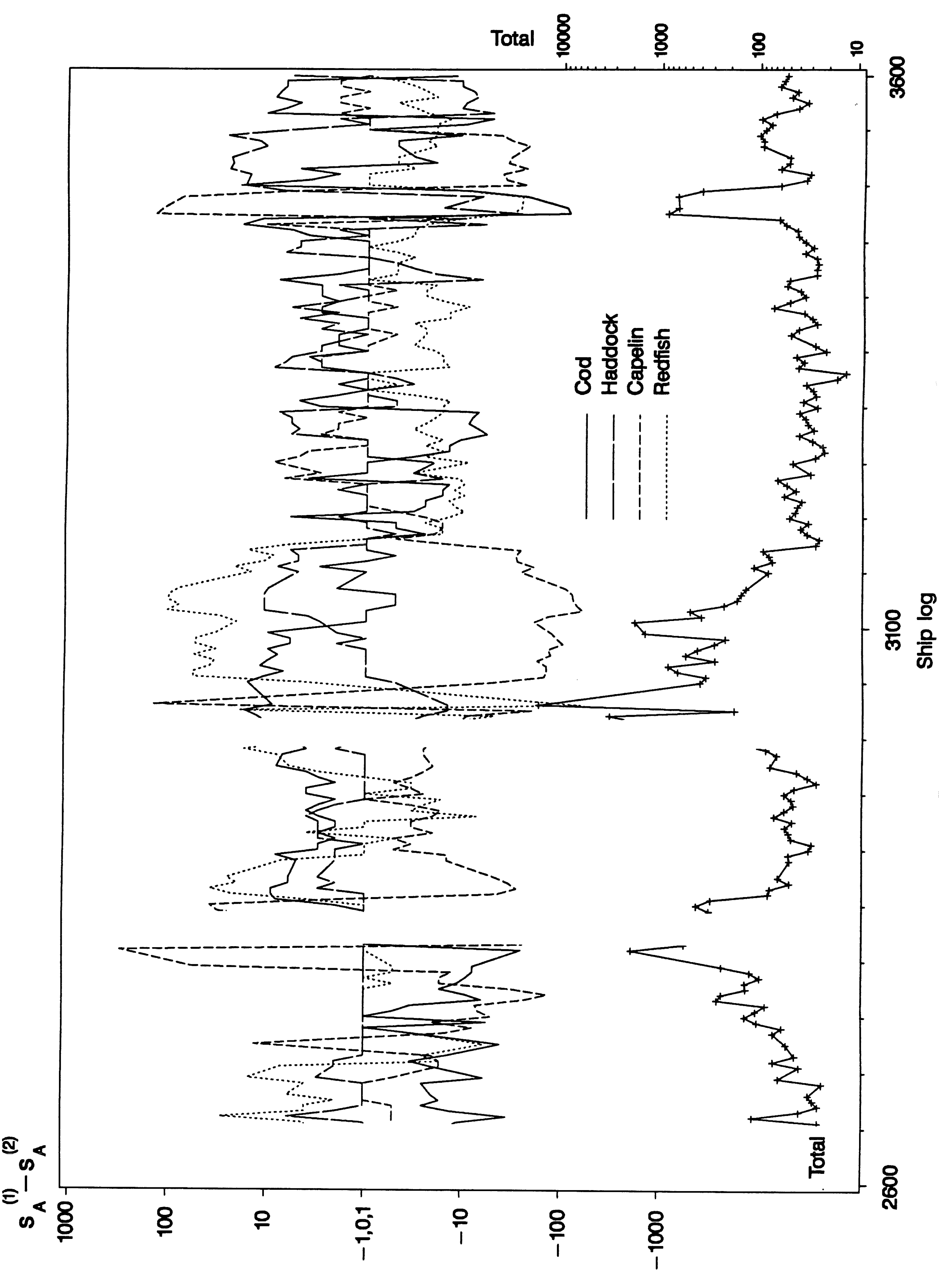


Figure 3

Differences between team-1 and team-2. A (typical) part of survey B.

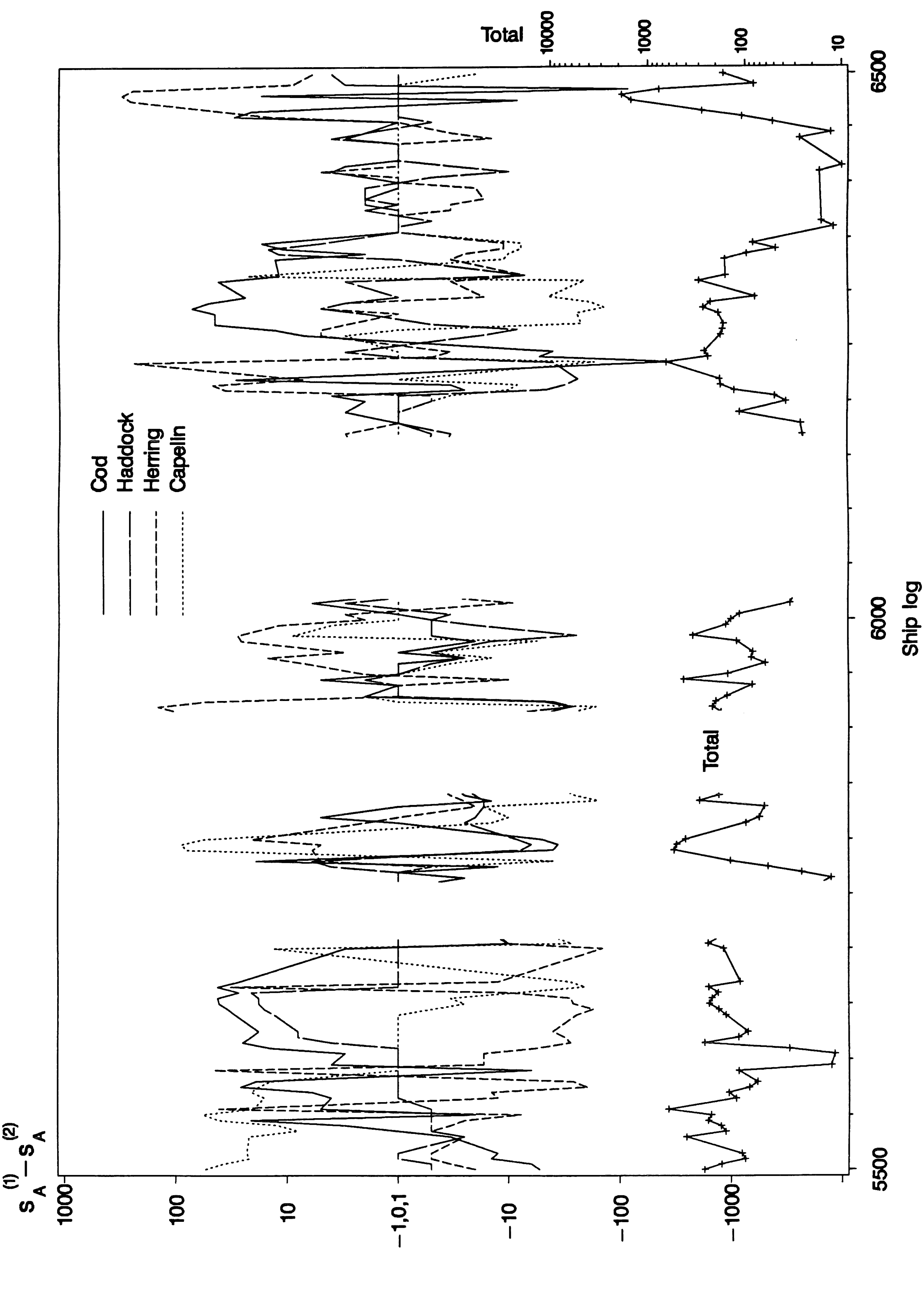


Figure 4

Differences between team-1 and team-2. A (typical) part of survey C.

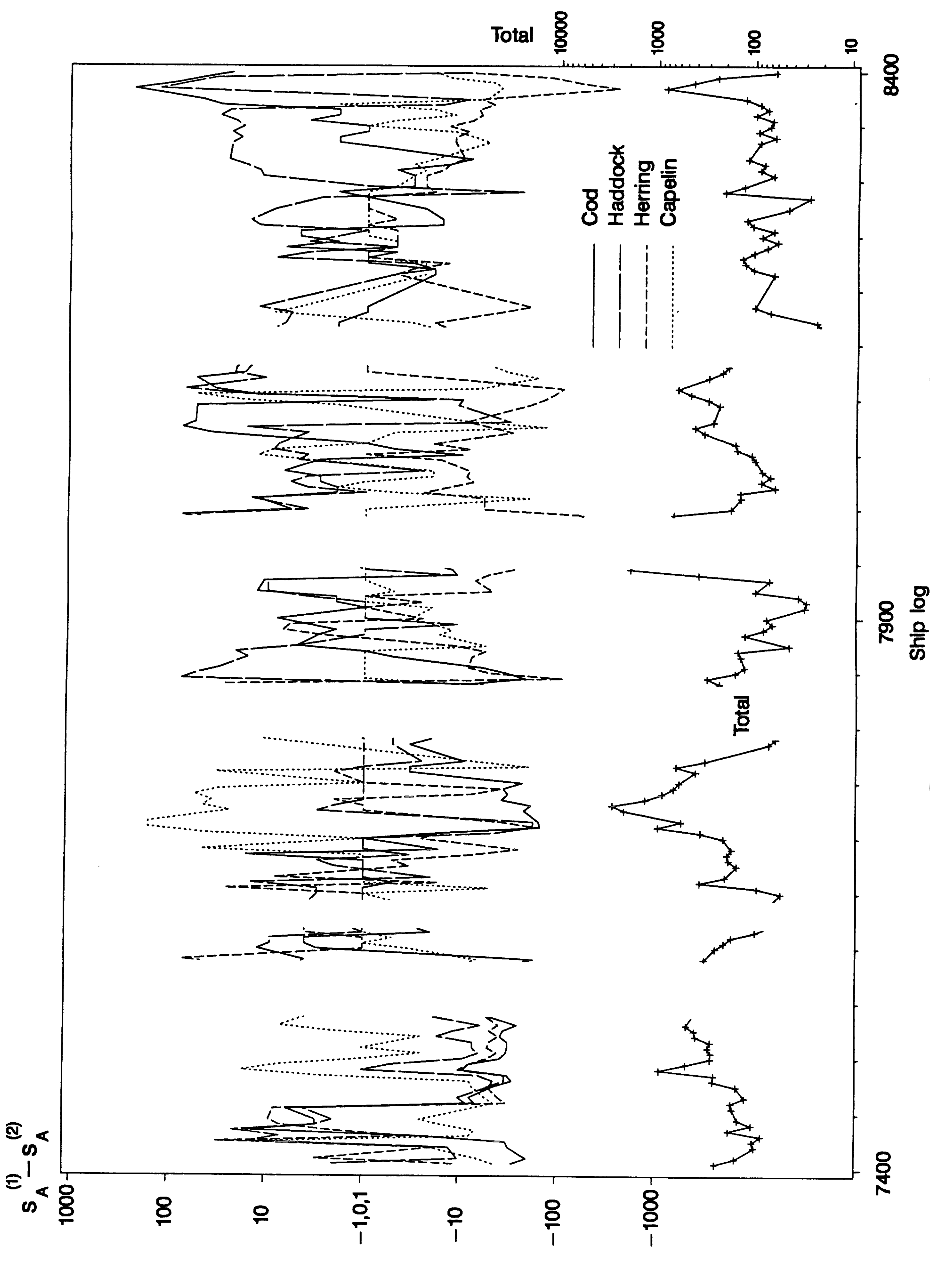


Figure 5

Differences between team-1 and team-2. A (typical) part of survey D.