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Results of the 1992 Aerial Survey of Capelin (Mallotus villosus) Schools Using the Compact Airborne Spectrographic Imager (CASI)

by

Brian S. Nakashima
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

Abstract

Aerial surveys were conducted over Trinity Bay and Conception Bay from June 21 to July 14, 1992 using a digital imaging spectrometer (CASI). The survey ended during the peak of the spawning run in Conception Bay and after the main run in Trinity Bay. The school surface area index was 750,045 m^2 which was the highest in the series.

Résumé

On a procédé à des relevés aériens au-dessus des baies de Trinity et de Conception du 21 juin au 14 juillet 1992, en se servant d'un spectomètre numérique d'imagerie (CASI). Ces relevés ont pris fin au plus fort de la remontée de frai dans la baie de Conception et après la remontée principale dans la baie de Trinity. L'indice de superficie du banc de poissons était de 750,045 m^2, soit le plus élevé de la série.

Introduction

Areal estimates of capelin (Mallotus villosus) schools conducted since 1982 have been used as an index of inshore abundance of mature capelin in NAFO Div. 3L (Nakashima 1992). From 1982 to 1989 school areas were measured from aerial photographs (eg. Nakashima 1990). Since 1990 school areas have been estimated from digital data collected by the Compact Airborne Spectrographic Imager (CASI) (Nakashima 1992). The digital images collected by the CASI and processed by image classification techniques are superior to results from the photographic method (Nakashima et al. 1989, Borstad et al. 1990, Borstad et al. 1992).

The report presents the results of the 1992 CASI aerial survey and compares the school surface area index to other indices of relative abundance of mature capelin.

Material and Methods

Instrument Operation

The CASI (Fig. 1) is an imaging spectrometer which uses a two dimensional (612 x 288) charge couple device (CCD) and a diffraction grating to collect image and spectral data. The CASI operates in the range of 423-946 nm. A 512 pixel width spatial image is formed in "pushbroom" fashion by reading out the cross track information as the aircraft moves forward. The remaining elements are used to obtain dark and electronic offset reference values. Spectral data are collected across 288 elements in the along track dimension of the array. The spectral resolution of each element is 1.8 nm and the spatial resolution of each element is 1.2 rad. Integration times are a function of ambient light levels, aircraft speed, and band selections.

In spatial or imaging mode the CASI operates like other pushbroom imagers except that band widths, positions and number are programmable during the flight. High spatial resolution imagery is collected in several spectral bands which can be programmed as narrow as 1.8 nm or wider. Different spectral band widths were used for sunny days and for overcast days:

Light condition	Band widths			
	1	2	3	4
Overcast	450-510	525-591	640-691	735-755
Sunny	476-501	525-590	651-671	744-755

Survey Method

Particulars of previous aerial surveys including aircraft type, camera and film used, survey time, and altitudes flown are listed in Table 1. CASI surveys in 1992 were flown at 1200 m to obtain a swath width comparable to aerial photographs taken at 457 m. Most of the images were obtained at altitudes close to 1200 m, however some flights were at lesser altitudes due to low ceilings (Table 1). The 1992 survey covered three transects as often as

possible; the inside of Trinity Bay from Gooseberry Cove to Hopeall Head, the outside of Conception Bay from Bay de Verde to Harbour Grace Islands, and the inside of Conception Bay from Bryant's Cove to Portugal Cove (Fig. 2). The fourth transect covering the outside of Trinity Bay was considered unnecessary (Nakashima 1992) and dropped from the 1992 survey.

During each flight capelin schools were detected by experienced spotters prior to digital recording of the area. Flight tapes and survey records were examined following each flight or shortly thereafter to assess the quality of the imagery.

Analytical Methods

CASI image data were transferred to a PC-based image processor for classification and analysis. Data were calibrated, roll-corrected, and set up as PCI image files. An algorithm, tested in 1989 to estimate school areas from the digital survey data (Borstad et al. 1990), was used to analyze the 1992 data. For each transect flown, the mean and median surface areas of capelin schools, the total number of schools, and the total surface area of all schools observed along a transect were estimated.

The school surface area index for each year was estimated by summing the highest total school surface area observed on each of the three transects. I assumed that the peak in school surface area was indicative of inshore abundance for each transect for that year (Nakashima 1985). The trend in the index derived from 1982 to 1992 was compared to trends in catch rates from capelin traps and purse seines (Nakashima 1993) and to projections of mature biomass (Anon. 1992, Nakashima 1992). Mature biomass projections were unavailable for 1991 (Anon. 1990).

Results and Discussion

In 1992, the aerial survey provided frequent coverage of the three transects. Trinity Bay was surveyed five times (Table 2a), the outside transect of Conception Bay four times (Table 2b), and the inside of Conception Bay seven times (Table 2c). Twelve days (June 21-23, 26, 28 and July 1-4, 7, 11-12) were lost because of poor weather conditions. In Trinity Bay the highest school area estimate was on July 8 (Table 2a). In Conception Bay only a few schools were present in June and early July with the highest amounts on July 13 and 14 when the survey ended (Tables 2b, c). The total school surface area taken from the highest estimates in Conception and Trinity Bays was 750,045 m^2.

Unlike 1991 when the survey was over before the main run of capelin schools had been observed close to spawning beaches (Nakashima 1992), the survey in 1992 ended as the peak in spawning was occurring. This observation is confirmed by the presence of spawn on Conception Bay beaches sampled immediately after July 14 (Nakashima and Slaney 1993). Also evidence from a beach monitoring programme found that capelin spawned at Chapel Cove in Conception Bay on June 26 and July 14 and at Bellevue Beach in Trinity Bay on July 7, 13-14, 30-31, and August 5-8. The highest egg deposition was observed on July 14 on both beaches (Winters and Nakashima, unpub. data).

The 1992 school surface area index suggests that mature capelin biomass was almost double the mean estimate of 369,644 m^2 for 1982 to 1990 (Table 3). The school surface area in 1991 was an underestimate because the aerial survey ended before capelin schools were present along the coastline to spawn (Nakashima 1992). The school surface area index suggests that mature biomass was high in 1992 which contrasts with the trap index which indicates a dramatic decline in 1992. However, the trap catch rate in 1992 was not indicative of inshore relative abundance because the trap index was based on only five traps (Nakashima 1993). At the $p = 0.05$ significance level, the NAFO projections are highly correlated with the purse seine and trap catch rate indices (Table 4). The trap catch rate index is not significantly correlated with the aerial survey index (Table 4). However, if we ignore the 1992 trap catch rate estimate then the trap catch rate series and aerial survey index from 1982 to 1990 are significantly correlated ($r = .7878$, $p = .0117$, Nakashima 1992).

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References

Anon. 1990. NAFO Scientific Council Reports. p. 145-146.

1992. NAFO Scientific Council Reports. p. 15-21.

Borstad, G. A., D. A. Hill, R. C. Kerr, and L. R. Armstrong. 1990. Development of a digital survey technique for operational aerial surveys of spawning capelin. Contract No. XA988-00115-(021) for the Dept. Fisheries and Oceans. 46 p.

Borstad, G. A., D. A. Hill, R. C. Kerr, and B. Nakashima. 1992. Direct digital remote sensing of herring schools. Int. J. Rem. Sensing 13: 2191-2198.

Nakashima, B. S. 1985. The design and application of aerial surveys to estimate inshore distribution and relative abundance of capelin. NAFO SCR Doc. 85/84, Ser. No. N1058. 11 p.

1990. Capelin school surface area index for NAFO Div. 3L during the 1989 spawning season. NAFO SCR Doc. 90/59, Ser. No. N1780. 6 p.

1992. Results of aerial surveys of capelin (Mallotus villosus) schools using the Compact Airborne Spectrographic Imager (CASI). NAFO SCR Doc. 92/5, Ser. No. N2038. 12 p.

1993. The capelin fishery in NAFO Div. 3L in 1992. DFO Atl. Fish. Res. Doc. 93/6. 22 p.

Nakashima, B. S., and R. W. Slaney. 1993. Capelin (Mallotus villosus) egg deposition on fifteen spawning beaches in Conception Bay, Newfoundland in 1992. DFO Atl. Fish. Res. Doc. 93/7. 11 p.

Nakashima, B. S., G. A. Borstad, D. A. Hill, and R. C. Kerr. 1989. Remote sensing of fish schools: early results from a digital imaging spectrometer, p. 2044-2047. In Proc. of IGARSS '89, 12th. Canadian Symposium on Remote Sensing, Vancouver, B.C., July 10-14, 1989.

Table 1. Summary of aerial surveys conducted from 1982 to 1992.

Year	Aircraft	Camera	Lens (mm)	Filter	Film	Radar altimeter	Survey period	Altitude (m)	Survey flight time (hrs)
1982	Piper Aztec	RC 10	152	Anti-vignetting	Aerocolour Neg. 2445	No	Jun 18-Jul 5	152-160	
1983	Aero-Commander	Wild RC 10	152	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 19-Jul 9	457	21.8
1984	Cessna 310	Wild RC 10	152	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 17-Jul 7	457	38.5
1985	Aero-Commander 500 B	Wild RC 10	152	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 18-Jul 3	290-610	28.6
1986	Aero-Commander 500 B	Wild RC 10	152	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 19-Jul 5	381-579	13.4
1987	Piper Aztec	Zeiss RMK	153	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 16-Jul 3	457	37.0
1988	Piper Navajo Piper Aztec	Zeiss RMK	153	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 15-Jul 5	305-488	33.0
1989	Piper Navajo	Zeiss RMK	153	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 16-27 Jun 30-Jul 4	434-732	26.0
1990	Piper Aztec	Zeiss RMK CASI	153	Anti-vignetting	Aerocolour Neg. 2445	Yes	Jun 17-Jul 6	570-1260	27.0
1991	Piper Navajo	CASI				Yes	Jun 21-25 Jul 3-17	1200	27.3
1992	Cessna 185	CASI					Jun 21-Jul 14	275-1280	34.6

Table 2a. Schooling data for the inside part of Trinity Bay from Gooseberry Cove to Hopeall, 1982-92.

Date	No. of schools	Total surface area (m^2)	School size (m^2)		
			Mean	SD	Median
June 19, 1982	31	12724	411	712	149
June 26, 1982	29	35607	1228	2755	299
June 29, 1982	11	62397	5672	8378	592
July 2, 1982	8	31365	3921	9281	705
July 3, 1982	2	1920	960	17	960
June 23, 1983	11	69583	6326	6299	4241
June 24, 1983	26	39004	1500	1880	753
June 25, 1983	30	174487	5816	12759	781
June 29, 1983	35	152557	4359	11139	781
June 30, 1983	46	199373	4334	6927	558
July 1, 1983	25	189497	7580	19791	2288
June 19, 1984	13	15624	1202	1770	335
June 23, 1984	9	8314	924	888	502
June 25, 1984	96	31526	328	505	117
June 26, 1984	96	40510	422	679	223
June 29, 1984	47	12053	256	314	167
July 3, 1984	57	23827	418	814	167
July 7, 1984	77	43245	562	1124	223
June 21, 1985	13	7041	542	706	270
June 25, 1985	35	22459	642	1144	211
June 26, 1985	30	16540	551	721	214
July 1, 1985	125	60245	482	963	181
July 2, 1985	130	195659	1503	6046[a]	179
June 28, 1986	59	95898	1625	4502	340
June 17, 1987	45	167567	3724	17727	223
June 19, 1987	91	399026	4385	31197	167
June 27-28, 1987	37	59315	1603	5612	446
July 3, 1987	5	1786	357	322	279
June 16, 1988	27	18749	694	902	391
June 19, 1988	50	104179	2084	4546	502
June 22, 1988	67	112863	1685	5749	391
June 25, 1988	20	87103	4338	15287[a]	474
July 5, 1988	23	32252	1402	3199	223
June 17, 1989	60	84349	1389	5040[a]	191
July 3, 1989	0				
June 24, 1990	4	69498	17375	11184	21483
June 27, 1990	30	58174	1831	3717	701
June 29, 1990	38	141122	3714	5486	1503
June 23, 1991	0				
June 24, 1991	0				
July 5, 1991	139	170681	1228	1827	535
July 14, 1991	54	64598	1196	1894	567
July 16, 1991	33	93680	2839	5562	800
June 25, 1992	29	40836	1408	1591	1078
June 29, 1992	71	97424	1372	1510	679
July 6, 1992	70	97565	1394	4273	267
July 8, 1992	124	173219	1397	3862	370
July 13, 1992	50	67889	1358	4008	263

a calculation excludes capelin in traps

Table 2b. Schooling data for the outside of Conception Bay from Bay de Verde to Harbour Grace Islands, 1982-92.

Date	No. of schools	Total surface area (m^2)	School size (m^2)		
			Mean	SD	Median
June 29, 1982	10	6577	658	366	642
July 2, 1982	2	1357	679	554	679
June 23, 1983	34	51838	1374	2266[a]	530
June 24, 1983	16	10658	666	823	447
June 25, 1983	4	4408	349	184	279
July 1, 1983	5	5413	1083	1884	112
June 18, 1984	1	391	391		
June 19, 1984	0	0			
June 25, 1984	49	63779	1294	2874	391
June 26, 1984	67	65956	697	1091[a]	279
June 30, 1984	21	22320	818	1509[a]	223
July 3, 1984	4	1786	446	599	195
June 20, 1985	0	0			
June 24, 1985	0	0			
June 27, 1985	30	8840	268	378[a]	120
June 28, 1985	125	50837	368	800[a]	132
June 29, 1985	22	19253	875	1169	291
July 1, 1985	28	28036	991	1616[a]	264
July 2, 1985	66	69166	914	2064[a]	223
June 19, 1986	88	132455	1462	2853[a]	279
June 16, 1987	139	184307	1322	2924[a]	391
June 19, 1987	143	112660	766	1516[a]	279
June 27, 1987	21	12164	539	559[a]	391
June 30, 1987	37	29462	790	1481[a]	279
June 20, 1988	54	36993	679	1099[a]	223
June 22, 1988	64	18916	230	324[a]	112
June 25, 1988	116	87534	676	1331[a]	279
July 4, 1988	51	39785	578	805[a]	279
June 16, 1989	180	266878	1483	5512	335
June 18, 1989	162	197372	1132	3607[a]	335
July 1, 1989	8	6140	730	1359[a]	198
June 24, 1990	89	85437	863	1483[a]	396
June 26-27, 1990	42	88759	1937	3671[a]	670
June 30, 1990	38	26013	686	771[a]	368
June 23, 1991	0				
June 24, 1991	0				
July 14, 1991	11	6374	579	2789	520
June 30, 1992	5	27150	5430	4668	2629
July 5, 1992	32	49308	1541	3383	558
July 9, 1992	45	135723	3016	6069	883
July 13, 1992	72	225838	3137	5026	1101

a calculation excludes capelin in traps

Table 2c. Schooling data for the inside of Conception Bay from Harbour Grace Islands to Portugal Cove, 1982-92.

Date	No. of schools	Total surface area (m^2)	School size (m^2) Mean • SD	Median
June 26, 1982 AM	33	19408	571 • 907[a]	135
June 26, 1982 PM	20	36513	1826 • 1914[a]	2089
June 27, 1982	48	151214	3134 • 6015[a]	527
June 29, 1982	27	30275	1121 • 1707	418
July 4, 1982	3	13042	4347 • 4951	1409
July 5, 1982	7	5127	732 • 582	592
June 23, 1983	53	97595	1787 • 2754[a]	558
June 24, 1983	30	56860	1819 • 2965[a]	558
June 25, 1983	29	79961	2677 • 3725[a]	781
June 30, 1983	7	8091	1156 • 1181	558
July 1, 1983	1	2009	2009	
June 18, 1984	0	0		
June 23, 1984	8	17689	2085 • 2556[a]	949
June 25, 1984	70	63891	879 • 1789[a]	223
June 26, 1984	33	23603	703 • 1708[a]	223
June 30, 1984	29	16852	508 • 467[a]	335
July 3, 1984	18	9040	329 • 254[a]	223
July 5, 1984	0	0		
June 20, 1985	0	0		
June 24, 1985	2	1600	800 • 834	800
June 26, 1985	17	10124	596 • 1145[a]	314
June 27, 1985	76	16552	214 • 426[a]	78
June 28, 1985	120	33858	274 • 938[a]	67
July 1, 1985	16	43228	2702 • 5140[a]	308
July 2, 1985	17	13436	676 • 1872[a]	191
June 19, 1986	39	31574	786 • 1105[a]	357
June 20, 1986	4	3515	698 • 769[a]	363
June 22, 1986	86	30930	343 • 616[a]	131
July 2, 1986	10	5019	502 • 600	358
June 17, 1987	196	53066	263 • 350[a]	167
June 19, 1987	365	205846	556 • 1482[a]	167
June 21, 1987	179	74128	393 • 699[a]	167
June 27, 1987	138	94747	681 • 2389[a]	167
June 28, 1987	63	68969	1036 • 2402[a]	167
June 30, 1987	41	51336	1226 • 2892[a]	391
July 3, 1987	47	34863	742 • 1400	279
June 19, 1988	77	25780	335 • 599[a]	223
June 20, 1988	31	7742	240 • 256[a]	167
June 24-25, 1988	289	201642	682 • 1091[a]	391
July 4, 1988	24	32141	1295 • 4242a	251
June 16, 1989	186	187311	991 • 2032[a]	319
June 18, 1989	113	88283	686 • 1422[a]	279
June 30, 1989	0			
July 1, 1989	22	13905	587 • 512[a]	396
July 4, 1989	24	10707	446 • 651	279

Table 2c. Continued ...

Date	No. of schools	Total surface area (m^2)	School size (m^2)		
			Mean	SD	Median
June 26, 1990	112	128743	1092	2960[a]	360
June 29, 1990	32	88310	2591	4544[a]	742
June 30, 1990	96	102615	1069	1993[a]	489
July 3, 1990					
June 25, 1991	0				
July 8, 1991	Few schools observed - no CASI data				
July 11, 1991					
July 17, 1991	8	8453	1057	531	875
June 24, 1992	8	4772	597	328	468
June 27, 1992	7	11726	1675	3478	133
July 5, 1992	12	24263	2708	2880	2143
July 6, 1992	23	10775	468	620	272
July 9, 1992	30	45748	1525	1865	792
July 13, 1992	63	148629	2359	3294	981
July 14, 1992	143	350988	2454	6098	751

a calculation excludes capelin in traps

Table 3. Comparison of three indices for estimating trends in relative spawning biomass. The catch/day index was based on capelin trap and purse seine data from logbook surveys (Nakashima 1993), the mature biomass index from NAFO Scientific Council Reports (Anon. 1982-89, 1992), and the school surface area index (this report).

Year	Catch (t)/day		Mature biomass (t)	School surface area (m^2)
	Purse seine	Trap		
1982	16.4	3.1	≥346,000	220,188
1983	18.8	3.4	648,000	348,806
1984	14.3	2.9	384,000	173,092
1985	16.4	4.6	596,000	308,053
1986	19.0	4.6	1,300,000	259,927
1987	18.1	8.8	2,830,000	717,532
1988	20.7	6.2	900,000	402,039
1989	24.3	6.7	3,345,000	538,538
1990	21.4	8.6	3,500,000	358,624
1991	16.2	7.3		185,508
1992	16.2	1.3	1,005,000	750,045

Table 4. Pearson product moment correlation coefficients for purse seine catch rate index (1982-92), capelin trap catch rate index (1982-92), aerial survey index (1982-90, 1992), and NAFO projections of mature biomass (1982-90, 1992). The upper right triangle presents the correlation coefficients and the lower left triangle are the probabilities. Number of comparisons are in parentheses.

	Purse seine	Trap	Aerial	NAFO
Purse seine	*	.4898 (11)	.2234 (10)	.7364 (10)
Trap	.1262	*	.2208 (10)	.8155 (10)
Aerial	.5349	.5399	*	.4642 (10)
NAFO	.0152	.0040	.1765	*

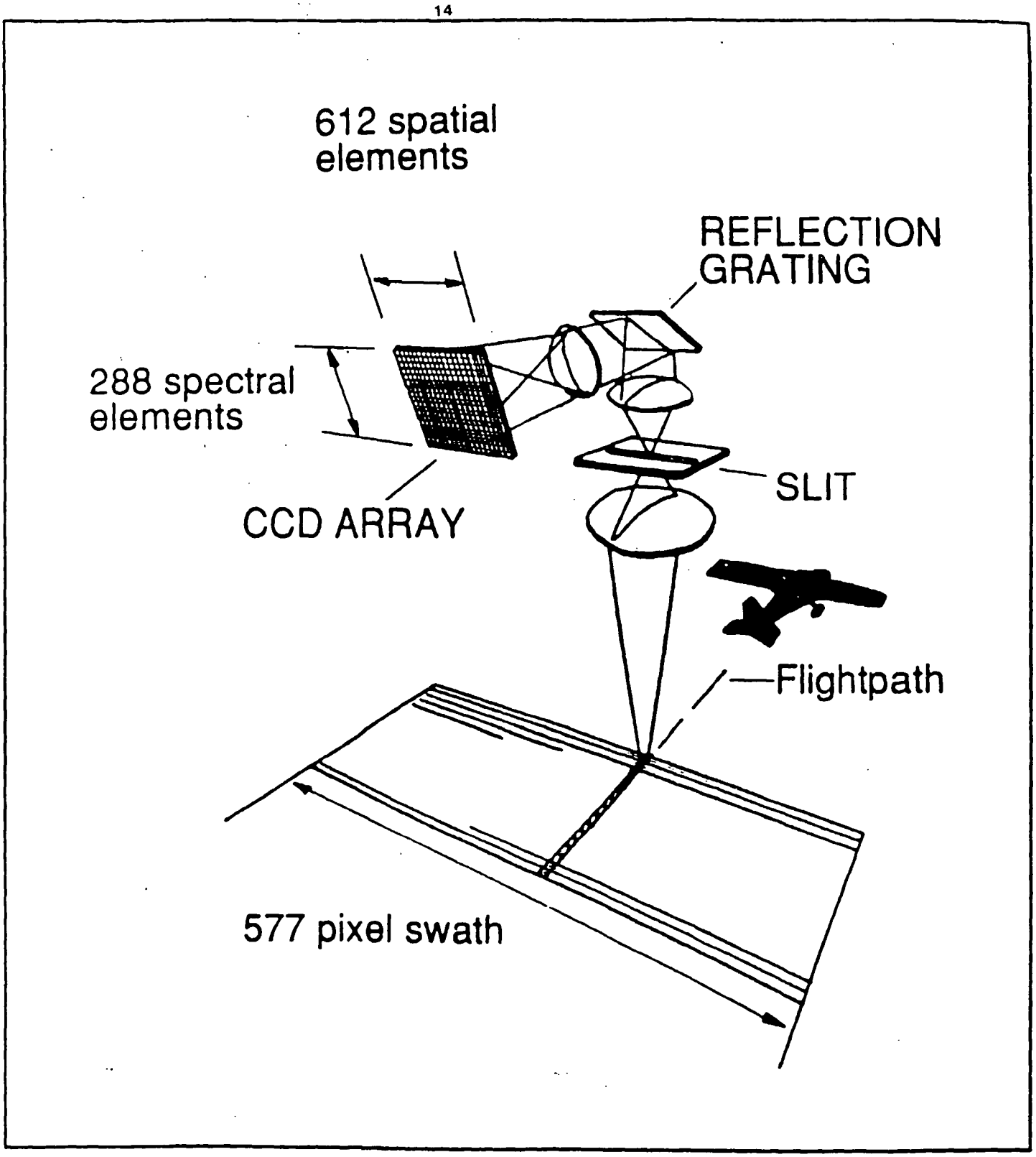

Fig. 1. Schematic of Compact Airborne Spectrographic Imager (CASI) from Borstad et al. (1990).

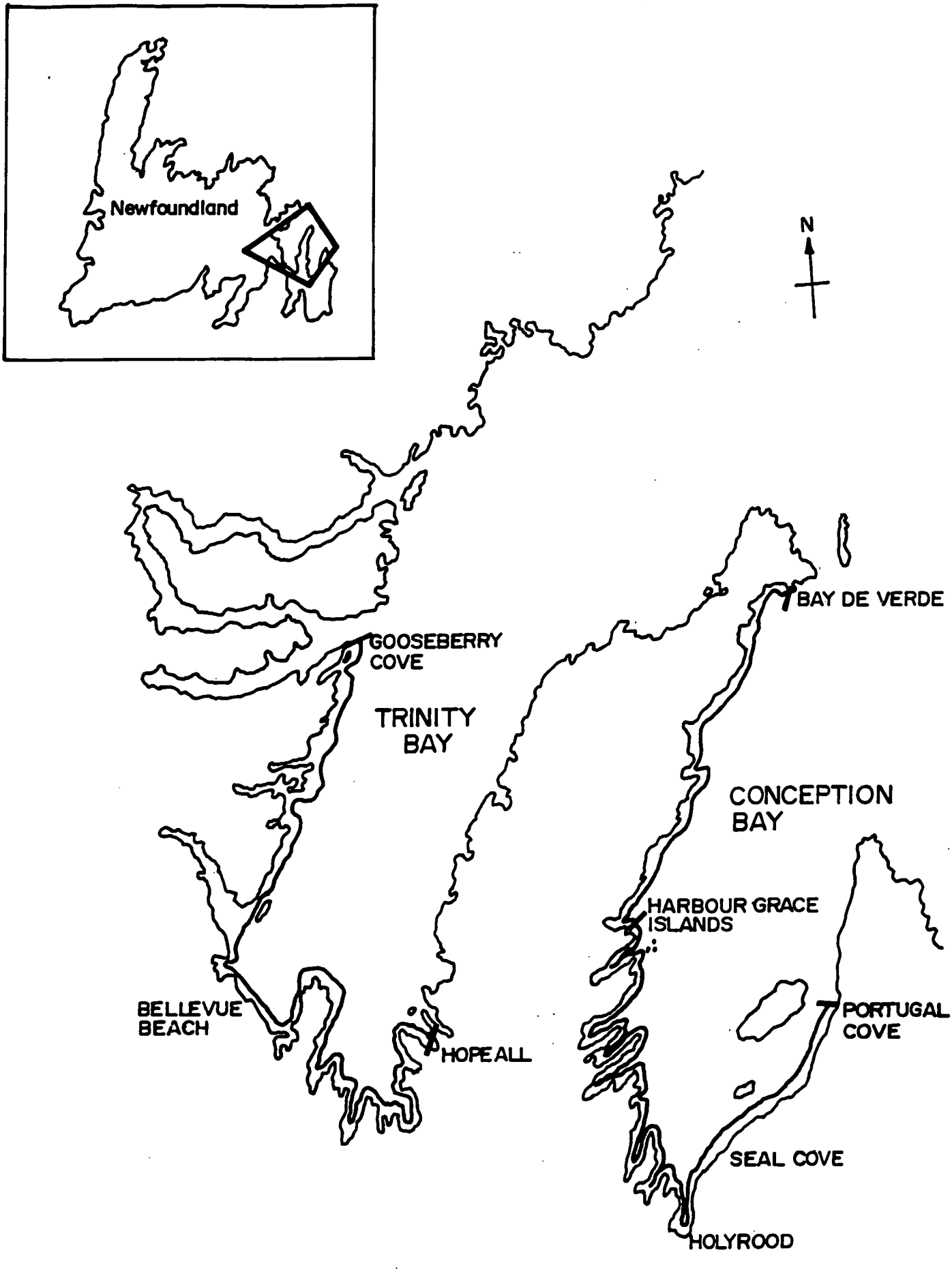

Fig. 2. Aerial survey transect for Trinity Bay and Conception Bay.