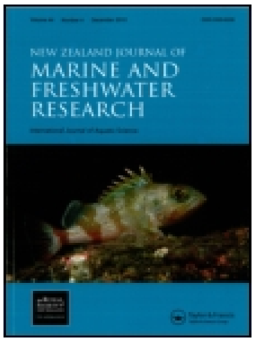

Taylor & Francis
Taylor & Francis Group

New Zealand Journal of Marine and Freshwater Research

ISSN: 0028-8330 (Print) 1175-8805 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzm20

Geographical variation in fin ray numbers in the New Zealand sand flounder Rhombosolea plebeia (richardson)

J. A. Colman

To cite this article: J. A. Colman (1976) Geographical variation in fin ray numbers in the New Zealand sand flounder Rhombosolea plebeia (richardson), New Zealand Journal of Marine and Freshwater Research, 10:3, 485-497, DOI: 10.1080/00288330.1976.9515631

To link to this article: http://dx.doi.org/10.1080/00288330.1976.9515631

Published online: 30 Mar 2010.

N.Z. Journal of Marine and Freshwater Research 10 (*3*) : 485–97. Sept. 1976

GEOGRAPHICAL VARIATION IN FIN RAY NUMBERS IN THE NEW ZEALAND SAND FLOUNDER *RHOMBOSOLEA PLEBEIA* (RICHARDSON)

J. A. COLMAN

Fisheries Research Division, Ministry of Agriculture and Fisheries, P.O. Box 19-062, Wellington, New Zealand

ABSTRACT

The numbers of dorsal and anal fin rays were compared in samples of sand flounder *Rhombosolea plebeia* (Richardson) collected from different localities around the coasts of New Zealand. Fin ray numbers were highest on the west coast of the North Island, particularly in the South Taranaki Bight, and were lowest on the east and south coasts of the South Island. Within the areas studied five regions were recognised within which the mean numbers of fin rays were relatively constant, but between which the mean numbers of fin rays differed considerably. The significance of these differences is discussed.

INTRODUCTION

The sand flounder *Rhombosolea plebeia* (Richardson) is one of the commonest and best known of the New Zealand flat fishes (order Heterosomata). It is found in most of the coastal waters of New Zealand down to depths of about 50 m. It is most abundant in Tasman Bay and off the east coast of the South Island where it supports trawl fisheries, but considerable quantities are also taken by commercial and amateur fishermen in other areas.

In view of the country-wide range of the sand flounder, studies were begun to determine whether the stocks of this species consist of a single, widespread population, or whether they are composed of a number of more or less isolated populations. Investigations of spawning grounds and spawning times are at present in progress, and fin rays have been counted on sand flounders taken in different parts of New Zealand. In this paper the results of these fin ray counts are presented, and the geographical variation in numbers of fin rays is examined.

The significance of meristic variation in fishes is a subject on which the opinion of ichthyologists has changed during the past. The question was reviewed and discussed by Barlow (1961), who came to the conclusion that variation of meristic characters is often under genetic control, although for any given genotype the environmental conditions

Received 12 August 1975.
Fisheries Research Division Publication 271.

can modify the precise numbers of meristic elements formed during development. Tåning (1952) also postulated some measure of genetic control, particularly among characters determined early in development, though he found that many environmental factors could influence the numbers of meristic elements.

Whatever the mechanism controlling meristic variation in fishes, large meristic differences between populations are unlikely to develop without some measure of isolation between the populations, as continual interchange of individuals will tend to prevent the development of genetic differences. However, meristic characters may differ on account of environmental differences during early development. Natural selection will act on such characters and, when isolation is complete, genetic differences between the populations may, in time, develop.

MATERIAL AND METHODS

The dorsal and anal fin rays were counted on about 2360 sand flounders, collected from localities round the coasts of New Zealand (Table 1, Fig. 1). Variability in numbers of rays in other fins was found to be much less than in the dorsal and anal fins. In particular, the pelvic and caudal fins were virtually constant at 6 and 18 rays respectively; pectoral fin rays varied in number from 10 to 13. Consequently only the dorsal and anal fin rays were counted on most fish.

The ages of fish were determined by otolith reading which has been shown to be a reliable method of aging sand flounders (Mundy unpublished 1968, Colman 1974).

Several different people were employed as counters during the work, but no serious problems were met in achieving accurate counts. On most fish, fin rays could be distinguished by naked eye, but on very small O-group fish a binocular dissecting microscope was used. Ray counts were not made when fins were mutilated or when fins or fish were abnormal in appearance.

For statistical analysis of the data, a sample of fish was taken to be all those fish caught in a given locality in any one calendar year. This was done to facilitate data handling and presentation, and to eliminate a large number of very small samples. The 40 samples so formed were pooled into 18 areas (Table 1, Fig. 1), the boundaries of these areas being chosen on the basis of geographical features.

With the exception of the Canterbury Bight region, the different areas were distinctly defined and separated by distance or by land masses. Within the Canterbury Bight the choice of boundary between the North and South Canterbury Bight and the Akaroa Heads area was arbitrary, but the decision to sub-divide the Canterbury Bight was justified on account of the possibility of a gradual change in fin ray numbers within the area being concealed by pooling all the data. The boundaries between the Akaroa Heads area and the North Canterbury Bight, and between

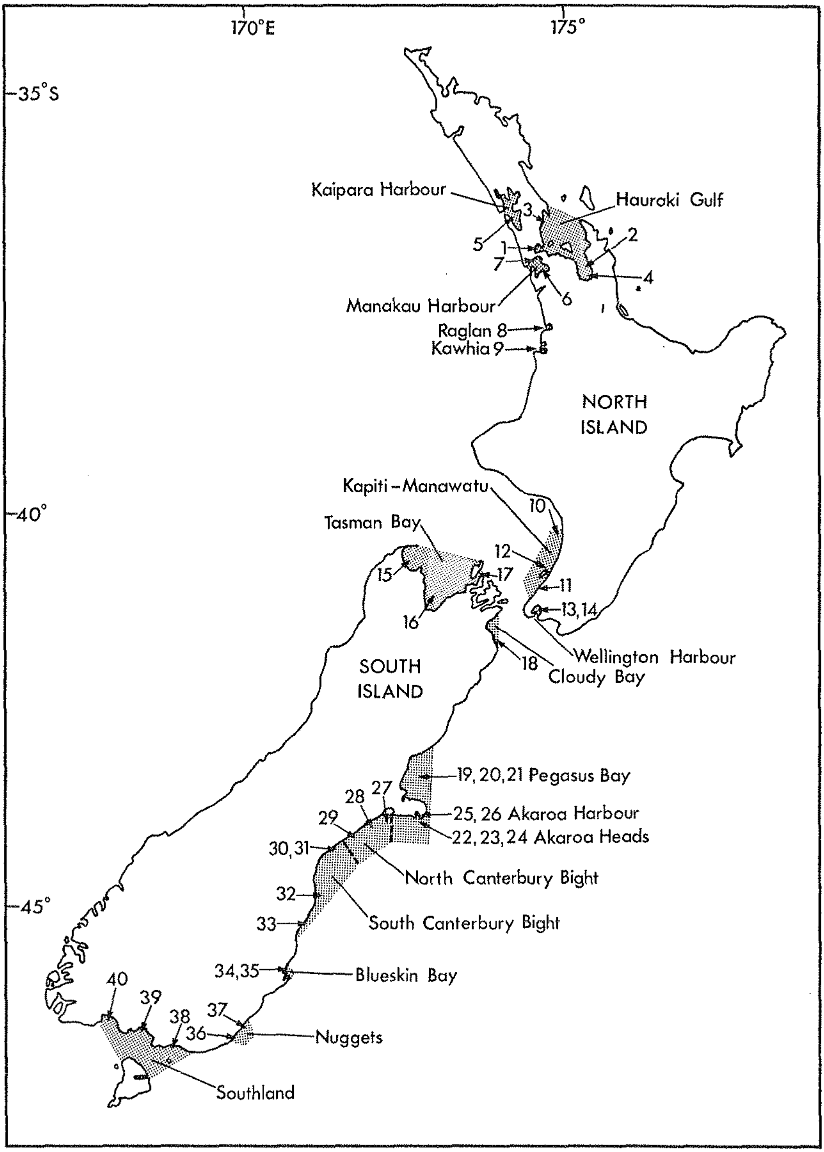

FIG. 1—Eighteen named areas in New Zealand coastal waters where sand flounder *Rhombosolea plebeia* were collected. See Table 1 for names of numbered localities.

TABLE 1—Numbers of fish (n), and mean numbers ($\bar{x}$) and standard deviations (σ) of fin rays in 40 samples of sand flounder *Rhombosolea plebeia*, 1968–75 (r/m = rivermouth, – = not calculated)

AREA	SAMPLE NO. & LOCALITY	WHEN COLLECTED	DORSAL FIN RAYS n	DORSAL FIN RAYS $\bar{x}$	DORSAL FIN RAYS σ	ANAL FIN RAYS n	ANAL FIN RAYS $\bar{x}$	ANAL FIN RAYS σ
HAURAKI GULF	1 Henderson Creek	Jan 1969	70	59.24	2.80	70	42.94	1.82
	2 Firth of Thames	Apr & Jun 1969	118	58.67	2.01	118	41.51	1.39
	3 Mahurangi	Aug 1969	4	57.75	0.50	4	41.75	1.26
	4 Thames	Jan 1973	15	59.73	1.91	15	42.27	1.62
KAIPARA	5 Shelly Beach	Aug 1969	9	59.67	2.55	9	43.67	1.80
MANUKAU	6 Weymouth	Jan 1969	26	61.85	2.17	26	44.46	1.24
	7 Taylors Bay	Aug 1969	194	61.07	1.86	194	43.77	1.51
RAGLAN	8 Raglan	Aug 1969	22	61.09	2.22	22	43.86	1.73
KAWHIA	9 Kawhia	Aug 1969	40	61.25	2.19	40	44.03	1.53
KAPITI-MANAWATU	10 Manawatu	Oct 1973	28	62.79	2.36	28	44.89	1.52
	11 Paremata	Jan & Jun 1969	86	63.07	2.46	86	44.80	1.93
	12 Kapiti Island	Aug 1973	9	63.33	2.92	9	44.67	1.58
WELLINGTON HARBOUR	13 Petone Beach	Jan & Jun 1969	81	59.81	2.03	81	42.58	1.60
	14 Petone Beach	Sep 1970	68	58.96	2.33	68	41.79	1.67
TASMAN BAY	15 Golden Bay	Aug 1969	27	59.74	2.16	27	42.70	1.55
	16 Tasman Bay	Jun Aug Oct 1973	661	59.16	2.27	661	41.85	1.61
ADMIRALTY BAY	17 Admiralty Bay	Oct 1973	8	60.88	2.47	8	43.13	1.96

Cloudy Bay	18 Cloudy Bay	Jun Jul Oct 1973	18	58.72	2.27	18	41.50	1.79
Pegasus Bay	19 Pegasus Bay	Jun & Oct 1973	62	56.73	1.87	62	40.84	1.45
	20 Pegasus Bay	Sep & Dec 1974	33	56.73	2.27	33	40.48	1.75
	21 Pegasus Bay	Mar 1975	77	56.16	1.99	76	40.82	1.34
Akaroa Heads	22 Akaroa Heads	Nov 1968	15	56.87	2.26	15	40.00	1.41
	23 Akaroa Heads	Mar 1969	18	56.78	1.86	18	40.67	1.41
	24 Akaroa Heads	Jun Sep Dec 1974	87	56.71	2.23	87	40.18	1.86
Akaroa Harbour	25 Akaroa Harbour	Jun & Dec 1974	101	55.53	2.17	102	39.92	1.61
	26 Akaroa Harbour	Mar 1975	127	56.50	2.20	123	40.56	1.33
North Canterbury Bight	27 Off L. Ellesmere	Dec 1974	11	56.55	1.63	11	40.18	1.66
	28 Rakaia r/m	Dec 1974	62	57.02	1.65	60	41.12	1.40
	29 Ashburton r/m	Dec 1974	2	55.50	–	2	39.50	–
South Canterbury Bight	30 Rangitata r/m	Dec 1968	10	57.90	1.10	10	42.10	1.60
	31 Rangitata r/m	Jun Sep Dec 1974	7	57.29	3.09	7	41.57	2.30
	32 Off Waimate	Jun Sep Dec 1974	23	58.00	2.66	23	41.30	1.55
	33 Off Oamaru	Sep Dec 1974	6	57.00	1.41	6	40.83	0.75
Blueskin Bay	34 Blueskin Bay	Nov 1968	12	58.17	1.34	12	40.83	1.27
	35 Blueskin Bay	Jun Sep Dec 1974	30	56.43	2.03	30	40.67	1.27
Nuggets	36 Nugget Point	Jul 1969	30	58.33	1.90	30	41.50	1.20
	37 Molyneux Bay	Jun Sep Dec 1974	40	57.60	2.70	40	41.23	1.75
Southland	38 Toetoes Bay	Sep 1974	2	58.50	–	2	43.00	–
	39 Riverton	Sep Dec 1974	34	57.32	2.23	34	41.06	1.81
	40 Te Wae Wae Bay	Sep Dec 1974	84	57.50	2.13	84	41.37	1.51

the North and South Canterbury Bight, were, respectively, a line running southwards from Lake Forsyth, and a line running south-east from a point halfway between the mouths of the Ashburton and Rangitata Rivers.

RESULTS

VARIATION WITH SEX AND YEAR

In areas where samples had been collected in more than one year, the mean numbers of dorsal and anal fin rays were compared between samples of fish taken in different years. A *t*-test was used to test the significance of differences between years (Table 2).

In 10 areas, samples had been collected in more than one year. In Wellington Harbour (counts of dorsal and anal fin rays), Tasman Bay (anal fin rays), Akaroa Harbour (dorsal and anal fin rays) and Blueskin Bay (dorsal fin rays), differences between years in mean numbers of fin rays were significant at least at the 5% level and, in four cases, at the 1% level. However, in all other areas the differences between years were not significant at 5%, and, in all except one (Blueskin Bay, dorsal fin rays), the differences were less than a single fin ray. Thus, although the possibility of variation in mean numbers of fin rays from year to year cannot be excluded, such variations can be expected to be slight and generally less than a single fin ray.

As a check on variation in mean numbers of fin rays between sexes, 515 sand flounders (223 females, 292 males) taken in Tasman Bay in 1973 were compared. No significant difference was found between sexes in the mean numbers of either dorsal or anal fin rays.

VARIATION BETWEEN SAMPLES AND BETWEEN AREAS

Pooling the 40 samples into 18 areas showed that there were considerable differences in mean numbers of fin rays between fish from different areas (Table 3). Plotting the mean numbers of dorsal fin rays against anal fin rays for fish in each area resulted in the 18 areas being clumped into a smaller number of larger regions (Fig. 2, Table 4). Within each region the mean numbers of dorsal and anal fin rays were reasonably consistent, but large differences in dorsal or anal fin rays, or both, were found between areas from different but neighbouring regions. The largest differences were between fish from Kapiti-Manawatu and Tasman Bay, and those from Kapiti-Manawatu and Wellington Harbour. In each case differences of over 3.5 dorsal and 2.5 anal fin rays were recorded. The affinities of the two smallest samples, from Kaipara Harbour and Admiralty Bay, could not be determined with any certainty, and more data are obviously needed from these areas.

To compare sources of variation between fish and between samples from different areas in different years the analysis of variance technique described by Gower (1962) and Gates & Shiue (1962) appeared to be

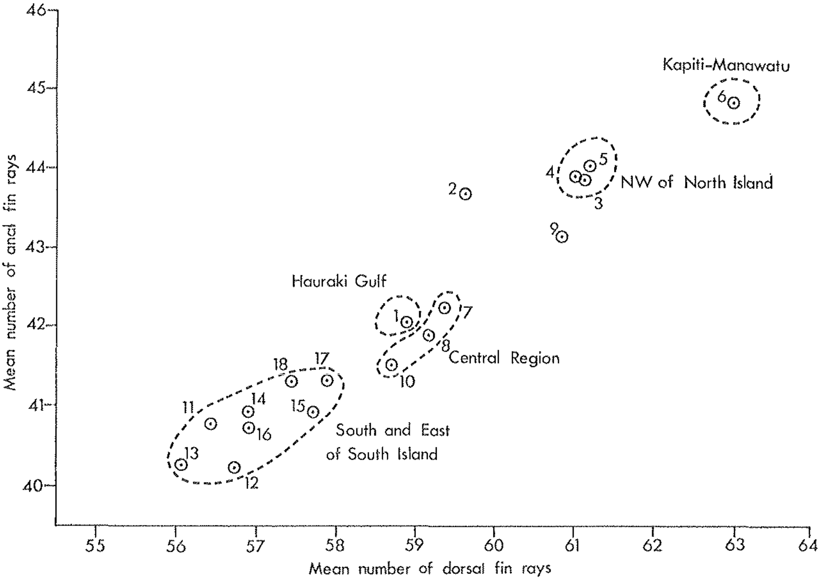

FIG. 2—Mean numbers of dorsal fin rays plotted against mean numbers of anal fin rays for sand flounder *Rhombosolea plebeia* collected in 18 areas.

suitable. This technique was summarised by Snedecor & Cochran (1967, pp. 291–4). First, however, Bartlett's test was used to check on the homogeneity of variance among fish in each of the samples. For dorsal and anal fin rays respectively, the values of Bartlett's chi-squared were 106.71 with 39 degrees of freedom, and 54.19 with 38 degrees of freedom (in one sample of only 2 fish, variance of anal fin rays was zero and this sample was omitted). These values were both significant, very highly so for dorsal fin rays ($P<0.001$), but less so for anal fin rays ($P = 0.04$).

Reasons for the heterogeneity of variance were not clear. Some samples were very small, and others showed a degree of skewness or kurtosis. There was also a tendency for variance to be higher among samples with larger mean numbers of fin rays. These sources of error may have been sufficient to account for the heterogeneity of variance in anal fin rays, but they could not explain the very high level of significance in dorsal fin rays. Thus, variance in numbers of fin rays could not be regarded as constant between samples, and therefore no reliable information may be obtained from analysis of variance.

TEMPERATURE EFFECTS

Numerous workers have reported variations in meristic characters with changes in environmental factors, principally temperature (see Barlow, 1961). New Zealand lies between latitudes of about 34.5° S at

TABLE 2—Comparison of mean numbers of fin rays ($\bar{x}$) in samples of sand flounder *Rhombosolea plebeia* taken in different years in the same areas ($m_1 - m_2$ = difference between sample means; t = value of 'Student's t'; n = number of fish in sample; σ = standard deviation of sample; S.E. = standard error of difference between means; * = t significant at 5%, ** = t significant at 1% level)

AREA	YEAR	n	$\bar{x}$	σ	YEARS COMPARED	S.E.	$m_1 - m_2$	t
DORSAL FIN RAYS								
Hauraki Gulf	1969	192	58.86	2.33	1969 & 1973	0.62	0.87	1.40
	1973	15	59.73	1.91				
Kapiti-Manawatu	1969	86	63.07	2.46	1969 & 1973	0.49	0.15	0.31
	1973	37	62.92	2.48				
Wellington Harbour	1969	81	59.81	2.03	1969 & 1970	0.36	0.85	2.36*
	1970	68	58.96	2.33				
Tasman Bay	1969	27	59.74	2.16	1969 & 1973	0.45	0.58	1.29
	1973	661	59.16	2.27				
Pegasus Bay	1973	63	56.73	1.87	1973 & 1974	0.44	0.00	0.00
	1974	33	56.73	2.27	1973 & 1975	0.33	0.57	1.73
	1975	77	56.16	1.99	1974 & 1975	0.43	0.57	1.33
Akaroa Heads	1968	15	56.87	2.26	1968 & 1969	0.74	0.09	0.12
	1969	18	56.78	1.86	1968 & 1974	0.63	0.16	0.25
	1974	87	56.71	2.23	1969 & 1974	0.57	0.07	0.12
Akaroa Harbour	1974	101	55.53	2.17	1974 & 1975	0.29	0.97	3.34**
	1975	127	56.50	2.20				
S. Canterbury Bight	1968	10	57.90	1.10	1968 & 1974	0.85	0.21	0.25
	1974	36	57.69	2.56				
Blueskin Bay	1968	12	58.17	1.34	1968 & 1974	0.65	1.74	2.68*
	1974	30	56.43	2.03				
Nuggets	1969	30	58.33	1.90	1969 & 1974	0.67	0.73	1.09
	1974	40	57.60	2.70				

ANAL FIN RAYS								
Hauraki Gulf	1969	192	42.04	1.70	1969 & 1973	0.46	0.23	0.50
	1973	15	42.27	1.62				
Kapiti-Manawatu	1969	86	44.80	1.93	1969 & 1973	0.36	0.04	0.11
	1973	37	44.84	1.52				
Wellington Harbour	1969	81	42.58	1.60	1969 & 1970	0.27	0.79	2.93**
	1970	68	41.79	1.67				
Tasman Bay	1969	27	42.70	1.55	1969 & 1973	0.32	0.85	2 66**
	1973	661	41.85	1.61				
Pegasus Bay	1973	62	40.84	1.45	1973 & 1974	0.34	0.36	1.06
	1974	33	40.48	1.75	1973 & 1975	0.24	0.02	0.08
	1975	76	40.82	1.34	1974 & 1975	0.31	0.34	1.10
Akaroa Heads	1968	15	40.00	1.41	1968 & 1969	0.49	0.67	1.37
	1969	18	40.67	1.41	1968 & 1974	0.50	0.18	0.36
	1974	87	40.18	1.86	1969 & 1974	0.46	0.49	1.07
Akaroa Harbour	1974	102	39.92	1.61	1974 & 1975	0.20	0.64	3.20**
	1975	123	40.56	1.33				
S. Canterbury Bight	1968	10	42.10	1.60	1968 & 1974	0.57	0.82	1.44
	1974	36	41.28	1.60				
Blueskin Bay	1968	12	40.83	1.27	1968 & 1974	0.43	0.16	0.37
	1974	30	40.67	1.27				
Nuggets	1969	30	41.50	1.20	1969 & 1974	0.37	0.55	1.49
	1974	40	41.23	1.75				

TABLE 3—Numbers of fish (n), mean numbers ($\bar{x}$), standard deviation (σ) and range in number of fin rays in sand flounder *Rhombosolea plebia* from 18 different areas

AREA	DORSAL FIN RAYS				ANAL FIN RAYS			
	n	$\bar{x}$	σ	Range	n	$\bar{x}$	σ	Range
Hauraki Gulf	207	58.92	2.31	50–66	207	42.05	1.69	38–48
Kaipara	9	59.67	2.55	56–64	9	43.67	1.80	41–46
Manukau	220	61.16	1.91	56–68	220	43.85	1.50	39–48
Raglan	22	61.09	2.22	56–69	22	43.86	1.73	40–49
Kawhia	40	61.25	2.19	56–66	40	44.03	1.53	40–48
Kapiti-Manawatu	123	63.02	2.45	57–69	123	44.81	1.81	39–48
Wellington Harbour	149	59.42	2.21	54–65	149	42.22	1.68	38–47
Tasman Bay	688	59.18	2.27	52–67	688	41.88	1.62	37–47
Admiralty Bay	8	60.88	2 47	58–64	8	43.13	1.96	41–47
Cloudy Bay	18	58.72	2.27	54–63	18	41.50	1.79	37–45
Pegasus Bay	172	56.47	2.01	51–61	171	40.76	1.47	36–44
Akaroa Heads	120	56.74	2.17	51–62	120	40.23	1.75	36–44
Akaroa Harbour	228	56.07	2.24	48–63	225	40.27	1.49	36–44
N. Canterbury Bight	75	56.91	1.66	53–60	73	40.93	1.48	38–44
S. Canterbury Bight	46	57.74	2.31	52–65	46	41.46	1.62	39–45
Blueskin Bay	42	56.93	2.00	51–61	42	40.71	1.25	38–44
Nuggets	70	57.91	2.40	52–62	70	41.34	1.53	38–46
Southland	120	57.47	2.14	52–65	120	41.31	1.60	38–45

North Cape and 47° S at Stewart Island, and within this range of latitude there are substantial differences in water temperature (Garner 1969).

The sand flounder spawns in winter and spring (Thomson & Anderton 1921, Colman 1973). The period during which the numbers of vertebrae and fin elements are determined occurs at some time during the early development of fishes (see Barlow (1961) and references therein). Water temperatures during winter and spring can be therefore expected to be of most significance in determining the numbers of meristic elements in the sand flounder.

At this time the water temperature is at its minimum, and there is little difference between the surface and bottom temperatures in shallow water down to 50 m, the habitat of the sand flounder. Off the west coast of the North Island, winter minima vary from about 14°C off Cape Reinga to about 13°C in the South Taranaki Bight (Garner 1969 and unpublished information in Ministry of Agriculture and Fisheries' records). In the Hauraki Gulf and in Tasman Bay the winter minima are 12–13°C. Off the south and east coasts of the South Island, temperatures fall lower, to about 9°C in Pegasus Bay and the Canterbury Bight, and to 10–11°C off South Otago and Southland. In all areas temperatures remain close to the winter minimum from June to September, after which they rise to reach the summer maximum in February.

Water temperatures are therefore lower around the south and east coasts of the South Island than elsewhere, and fin ray numbers are markedly lower among sand flounders taken in these waters. However,

TABLE 4—Numbers of fish (n), mean numbers ($\bar{x}$), standard deviation (σ) and range in numbers of fin rays among sand flounder *Rhombosolea plebeia* from five different regions round New Zealand

REGION	DORSAL FIN RAYS				ANAL FIN RAYS			
	n	$\bar{x}$	σ	Range	n	$\bar{x}$	σ	Range
Hauraki Gulf	207	58.92	2.31	50–66	207	42.05	1.69	38–48
NW of North I (Kaipara, Manukau, Raglan, Kawhia)	291	61.12	2.00	56–69	291	43.87	1.52	39–49
S. Taranaki Bight (Kapiti, Manawatu)	123	63.02	2.45	57–69	123	44.81	1.81	39–48
Central (Tasman, Admiralty, Cloudy Bays, Wellington Harbour)	863	59.23	2.27	52–67	863	41.94	1.64	37–47
S & E of South I	873	56.78	2.21	48–65	867	40.73	1.60	36–46

from north to south on the North Island west coast the numbers of fin rays increase although water temperatures decrease. Also, although water temperatures off the south-west coast of the North Island are similar to those in Tasman Bay, large differences in fin ray numbers were recorded between sand flounders from these two areas. No consistent correlation could be found between numbers of fin rays and water temperature during spawning.

Thus the role of water temperature in determining fin ray numbers in the sand flounder is only a minor one, and its effects, if any, are masked by much larger variations in fin ray numbers caused by other factors. Lux *et al.* (1970) came to similar conclusions for winter flounder *Pseudopleuronectes americanus* (Walbaum) off Massachusetts. Until some experimental evidence is available, the effects of temperature and other environmental factors on the determination of fin ray numbers in the sand flounder cannot be accurately estimated.

DISCUSSION

Round the south and east of the South Island, differences in mean numbers of fin rays between areas were generally small (Table 4). These differences never exceeded 1.0 dorsal or 0.7 anal fin rays. Nevertheless, there was a gradual increase in numbers of fin rays from north to south, at least to as far south as Nugget Point.

Within this cline there were a number of irregularities. One was the very low mean numbers of dorsal and anal fin rays among the sand flounders in Akaroa Harbour, and the low mean number of anal fin rays among those from Akaroa Heads. Another was the apparent reversal of the cline between the South Canterbury Bight and Blueskin Bay. A third was the very low variance in fin ray numbers among fish from the

North Canterbury Bight. Further sampling from these areas would be helpful in determining whether these anomalies are real features or whether they could be caused by sampling errors.

Similar clines probably exist in other parts of the country. Further collections should determine whether the differences in fin ray numbers between regions round the North Island, or between Pegasus Bay and Cloudy Bay, are gradual or abrupt. The gradual changes round the south and east coasts of the South Island suggest that the sand flounder stocks in these waters may be connected with each other, although there is probably little interchange of individuals between widely separated areas within the region. Whether the differences are due to genetic or to environmental factors cannot be determined from the information at present available. The large differences between fish in the Kapiti-Manawatu area and those in Tasman Bay suggest that genetic factors may be involved in this instance.

Further work is clearly necessary to determine the nature of differences in fin ray numbers between fish from many areas. Observations on the mean numbers and variances of fin rays in several successive year classes in the same area would be of value in determining year-to-year variability. Such studies could be combined with observations on relevant environmental factors in order to assess the effects of these factors in determining numbers of fin rays.

The mean numbers of fin rays in the sand flounder remain fairly constant within any given locality, and variation in environmental factors is probably of only minor importance in determining fin ray numbers. Nevertheless, some variation in mean numbers of fin rays can be expected from year to year, although the significance of small differences between areas, of the order of 1 dorsal or 0.75 anal fin rays, is doubtful.

ACKNOWLEDGMENTS

I wish to thank all concerned in the collection of material and in the laborious counting of the fin rays. Thanks also to colleagues in the Fisheries Research Division who read and criticised the manuscript.

LITERATURE CITED

BARLOW, G. W. 1961: Causes and significance of morphological variation in fishes. *Systematic Zoology 10*: 105–17.

COLMAN, J. A. 1973: Spawning and fecundity of two flounder species in the Hauraki Gulf, New Zealand. *N.Z. Journal of Marine and Freshwater Research 7 (1 & 2)*: 21–43.

——— 1974: Growth of two species of flounders in the Hauraki Gulf, New Zealand. *N.Z. Journal of Marine and Freshwater Research 8* (2): 351–70.

GARNER, D. M. 1969: The seasonal range of sea temperatures of the New Zealand shelf. *N.Z. Journal of Marine and Freshwater Research 3* (2): 201–8.

GATES, C. E. & SHIUE, C. 1962: The analysis of variance of the *S*-stage hierarchical classification. *Biometrics 18*: 529–36.

GOWER, J. C. 1962: Variance component estimation for unbalanced hierarchical classifications. *Biometrics 18*: 537–42.

LUX, F. E., PETERSON, A. E. & HUTTON, R. F. 1970: Geographical variation in fin ray number in winter flounder, *Pseudopleuronectes americanus* (Walbaum) off Massachusetts. *Transactions of the American Fisheries Society 99* (*3*): 483–8.

MUNDY, A. R. unpublished 1968: The biology of the sand flounder, *Rhombosolea plebeia* (Richardson) off Canterbury, New Zealand. Ph.D. thesis lodged in University of Canterbury library, Christchurch, New Zealand. 151 pp.

SNEDECOR, G. W. & COCHRAN, W. G. 1967: "Statistical Methods". 6th edition. Iowa State University Press. 593 pp.

TÅNING, A. V. 1952: Experimental study of meristic characters in fishes. *Biological Reviews of the Cambridge Philosophical Society 27*: 169–93.

THOMSON, G. M. & ANDERTON, T. 1921: History of the Portobello Marine Fish-hatchery and Biological Station. *N.Z. Board of Science and Art Bulletin 2*. 131 pp.