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Influence of environmental factors on condition index and biochemical composition in *Mytilus edulis* L. in cultivated-raft system, in two Scottish Sea Lochs

İskoçya'da iki deniz gölünde, raft sisteminde yetiştirilen *Mytilus edulis*'lerin kondisyon faktörü ve biyokimyasal özellikleri üzerine çevresel faktörlerin etkisi

Sedat Karayücel* and İsmihan Karayücel**
*University of Ondokuz Mayıs, Faculty of Fisheries 57 000 Sinop/Turkey
**Institute of Aquaculture, University of Stirling, Stirling FK9 4LA Scotland/UK

Abstract

The effect of environmental parameters: salinity, temperature, seston, particulate organic matter (POM) and chlorophyll-a (Ch-a) on condition index and biochemical composition of *Mytilus edulis* L. in suspended raft culture in Loch Etive (LE) and Loch Kishorn (LK) were studied from May 1993 to August 1994. The condition indices: wet meat volume condition index (CIV) and dry meat weight condition index (CID) and meat yield (MY) of cultivated mussels showed a similar pattern at 2m and 6m at the both sites. CIV was found to be 41.82% and 57.15% while CID was 9.77 and 12.54 in LE and LK respectively. Site, but not depth, had a significant effect on the condition indices, with the latter being significantly higher in LK than LE ($P<0.05$). Mainly condition of mussels was affected by temperature and salinity in LE. However temperature had a main significant effect on condition index in LK.

Mean protein was found to be 59.99±1.73% in LK and 56.13±1.85% in LE while mean value of carbohydrate 29.07±2.58% and 31.16±3.14% in LK and LE respectively. Carbohydrate had an inverse relationship with protein. Lipid was found to be 9.74±0.3% and 10.6±0.31 while ash values obtained were 8.05±0.44% and 7.36±0.43 % in LK and LE respectively. Mean moisture was 79.39±0.74% in LE and 79.17±0.78% in LK. Carbohydrate and lipid showed a positive relationship while protein and lipid were inversely related. Moisture and ash correlated positively with protein while they had a negative relationship with carbohydrate and lipid at both sites.

Keywords: *Mytilus edulis*, environmental factors, condition index, biochemical composition

*Correspondence Address: University of Ondokuz Mayıs, Faculty of Fisheries 57 000 Sinop/Turkey

Introduction

The blue mussel (*Mytilus edulis* L.) is cultivated in suspended mussel culture systems until a marketable size (>50mm) with about 1000 metric tons production capacity in Scotland (Karayücel, 1997). Local variations in the marine environment have significant effects on growth and condition of mussels (Karayücel, 1996). Biological indices that measure response of marine animals, such as molluscs, to changing environmental parameters have been widely employed (Austin *et al.*, 1993; Dare and Edwards, 1975; Gabbot and Bayne, 1973). Condition index is the general term referring to meat quality of bivalves that is most often assessed for biological and economic purposes (Baird, 1958).

Meat yield might provide the most practical and meaningful measure of condition of mussels for the industry and that significantly correlated with wet meat volume condition index (CIV) and dry meat weight condition index (CID) (Hickman *et al.*, 1991). Effect of environmental factors on condition index and biochemical composition have been studied by many researchers in molluscs (Austin *et al.*, 1993; Dare and Edwards, 1975; Gabbot and Bayne, 1973; Littlewood and Gordon, 1988; Ruiz *et al.*, 1992; Walne, 1970; Zandee *et al.*, 1980). Condition index may be used to follow seasonal changes in gross nutrient reserves or indicate differences in commercial quality (meat yield) of bivalve populations (Grosby and Gale, 1990). Changes in biochemical composition are usually reported as differences in the level of a given constituent (% dry weight) or as changes in biochemical content (weight per animal) (Giese, 1967). Most determinations of biochemical composition of marine bivalves have been concerned with the gross changes in protein, lipid and carbohydrate content (Gabbot, 1976).

The indication that parasites stress their host, affecting a wide variety of biochemical and physiological functions, is well documented (Lauckner, 1983). The seasonal variation in glycogen content reflects the interaction between food availability, temperature, growth and reproductive cycle (Zandee *et al.*, 1980). The loss of protein and glycogen was attributed to food scarcity (Ansel, 1972) and the metabolic demands for gametogenesis (Widdows and Bayne, 1971). Protein is a major source of energy during gonad maturation (Mann and Glomb, 1978). Bayne *et al.* (1978) suggested that a simultaneous regression and resorption of previously formed gametes occured in *Mytilus edulis* under temperature stress or a lack of food.

There is a lack of study on mussel culture, condition index and biochemical composition in mussel on the west coast of Scotland. The present study provides detailed data on the seasonal variation in two different condition indices, meat yield, energy, biochemical composition and spawning of raft cultivated mussels. Results might be useful for mussel farmers to chose the best time for harvesting and use meat yield instead of condition index to determine condition and health of mussels.

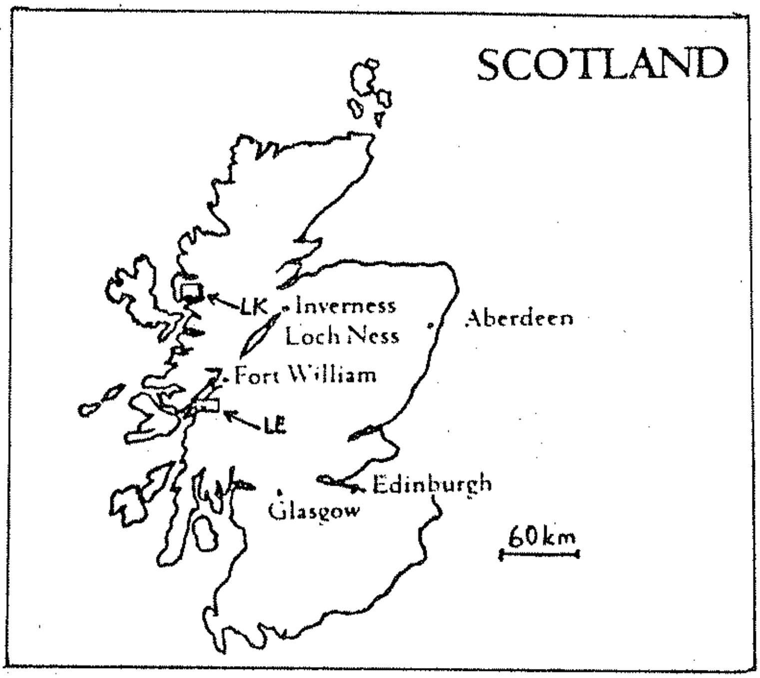


Figure 1 Map of Scotland shows experimental sites.
LE: Loch Etive, LK: Loch Kishorn.

Materials and Methods

The experiment was carried out in two sea lochs; Loch Etive (LE) and LK Loch Kishorn (LK) on the west coast of Scotland (Fig. 1). Investigations on mussel condition index, biochemical composition and environmental factors were conducted from May 1993 to August 1994. On each sampling date, salinity and temperature were measured with Salinity Temperature Bridge (M.C.5) at 2 m and 6 m depth. One litre water samples were taken in duplicate using a Nansen type sampling bottle for chlorophyll-a (Ch-a), Particulate Organic Matter (POM), percentage of POM (POM%), seston determination and particle count at these two depths. All samples were passed through a 150 µm nylon mesh to remove large particles. Chlorophyll-a was determined according to spectophotometric methods (Strickland and Parson,1972). A computer program was used to find the Ch-a concentration in the samples according to Stirling (1985). Seston, POM and POM% were measured according to Stirling (1985). A quantitative analysis of particle counts was carried out by an electronic particle counter (Counter Multisizer U.K.). Cuvettes containing 15 l of Isoton and a 5 l sub-samples of sea water were each placed in the counter. Each sample was counted three times and the mean number of the particles (PN) calculated, taking account of the relative amounts of sea water and Isoton. A black and white painted Secchi disk was used to measure transparency.

One year old mussels were collected from a suspended raft culture system up to a marketable size (>50 m) from 2 m and 6 m depths for condition indices and meat yield. Samples were transferred to the laboratory in a cool box. Samples from two depths were pooled for biochemical composition evaluation. Condition indices, measurement of shell length and meat yield (about 50 animals) were carried out one day after sampling. Mussels dry meat samples were kept in deep-freezer awaiting biochemical analyses and they were dried before biochemical analyses. Condition index wet meat volume (CIV) was assessed by measuring the volume of shell cavity and volume of meat (Lutz *et al.*, 1980). Condition index dry meat weight (CID) was found after drying the wet meat (Baird, 1958; Lutz *et al.*, 1980; Austin *et al.*,1993) from the following equations:

$$\text{Wet meat volumetric condition index} = \frac{\text{Volume of soft tissue (ml)}}{\text{Volume of shell cavity (ml)}} \times 100$$

$$\text{Dry weight condition index} = \frac{\text{Weight of dry tissue (g)}}{\text{Volume of shell cavity (ml)}} \times 100$$

Meat yield was estimated from following formula :

$$\text{Meat yield (\%)} = \frac{\text{Wet meat weight (g)}}{\text{Total weight (g)}} \times 100$$

Twenty five mussels were used to measure each condition index for each depth of the raft culture system. The volume of the five groups of five mussels was found by using 50, 100 and 250 ml measuring cylinder depending on mussel size. They were then opened and blotted with tissue paper, put into a measuring cylinder and their volume measured by direct water displacement. Shell volume was measured in the same way. The shell cavity volume was estimated as the difference between the whole animal volume and shell volume. Meats were dried at 105°C for 20 hours to obtain their dry weight and moisture content. Ash weight was determined by combusting a known dry weight of tissue at 500°C for 15 hours in the muffle furnace and reweighing the tissue.

Triplicate dry meat samples were analyzed for lipid, protein, carbohdrate and energy according to AOAC (1990) methods. Protein was determined using a Micro-Kjeldahl technique (Kjeltec 1030, Tecator), lipid by solvent extraction (Soxtec HT, Tecator). Carbohydrate samples were analysed in triplicate. The energy content of dry meat was determined by bomb calorimetry (Gallenkamp Autobomb CBA-500).

A paired student's *t* test was applied to the environmental data to compare differences in conditions between the depths while unpaired student's *t* test conducted to find differences between the sites. Two-way ANOVA was applied to test the differences in condition indices, meat yield between depths and sites while one-way ANOVA was used to test differences in biochemical parameters between the sites. A correlation matrix was used to examine correlation between all the measured parameters at each loch. All percentage data were converted to the arcsine before statistical analyses (Zar, 1984).

Results

Environmental results

Mean values of environmental factors at 2 m and 6 m depths are shown in Table 1 and interactions between environmental factors are given in Tables 3 and 4. Temperature followed a similar pattern at both sites and depths and was mainly affected by season. Differences in temperature between depths and sites were not significant ($P>0.05$), with a range from 4.6°C to 15.7°C in Loch Etive (LE) and 5.5°C to17°C in Loch Kishorn (LK). Low temperatures were caused by cool freshwater run-off from surrounding mountains and rivers in LE and by tidal range and local fresh water run-off in LK. In general, salinity was high in summer and low in winter and spring in both sites. In LE, there was high fluctuations

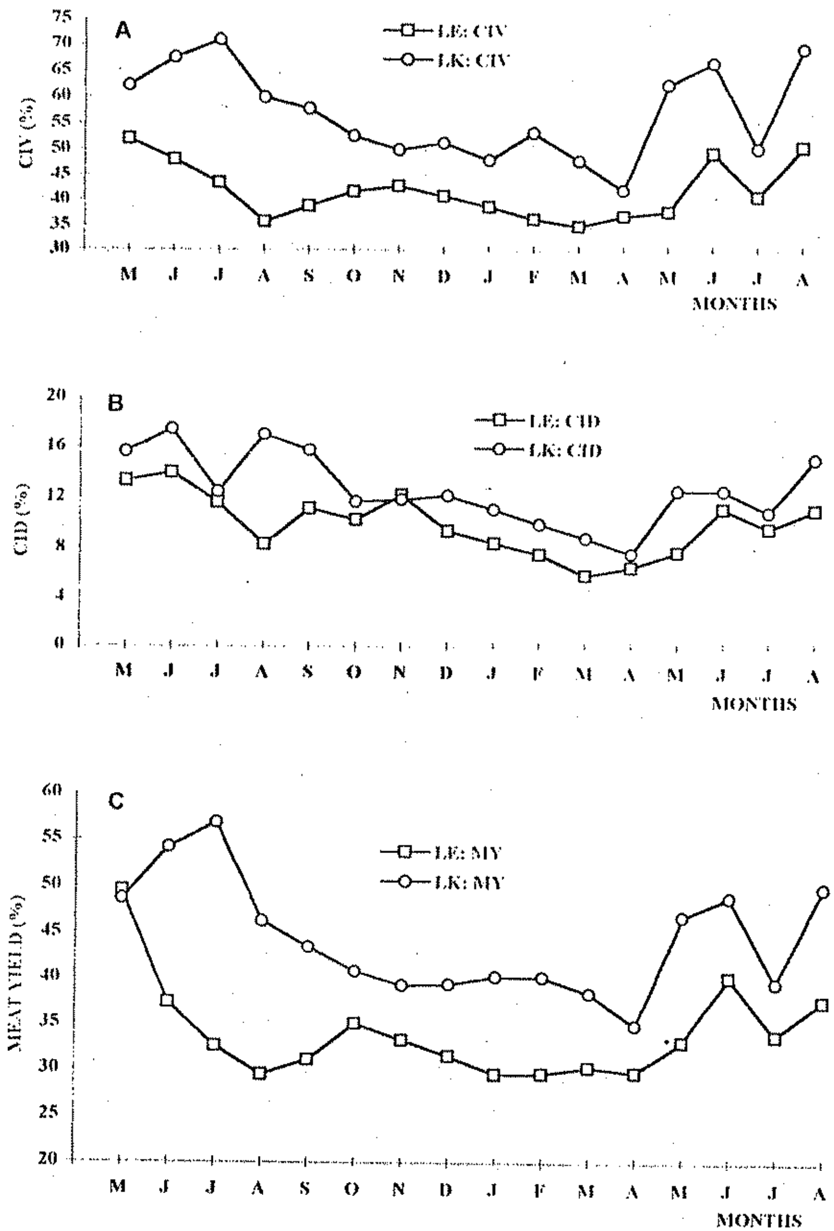
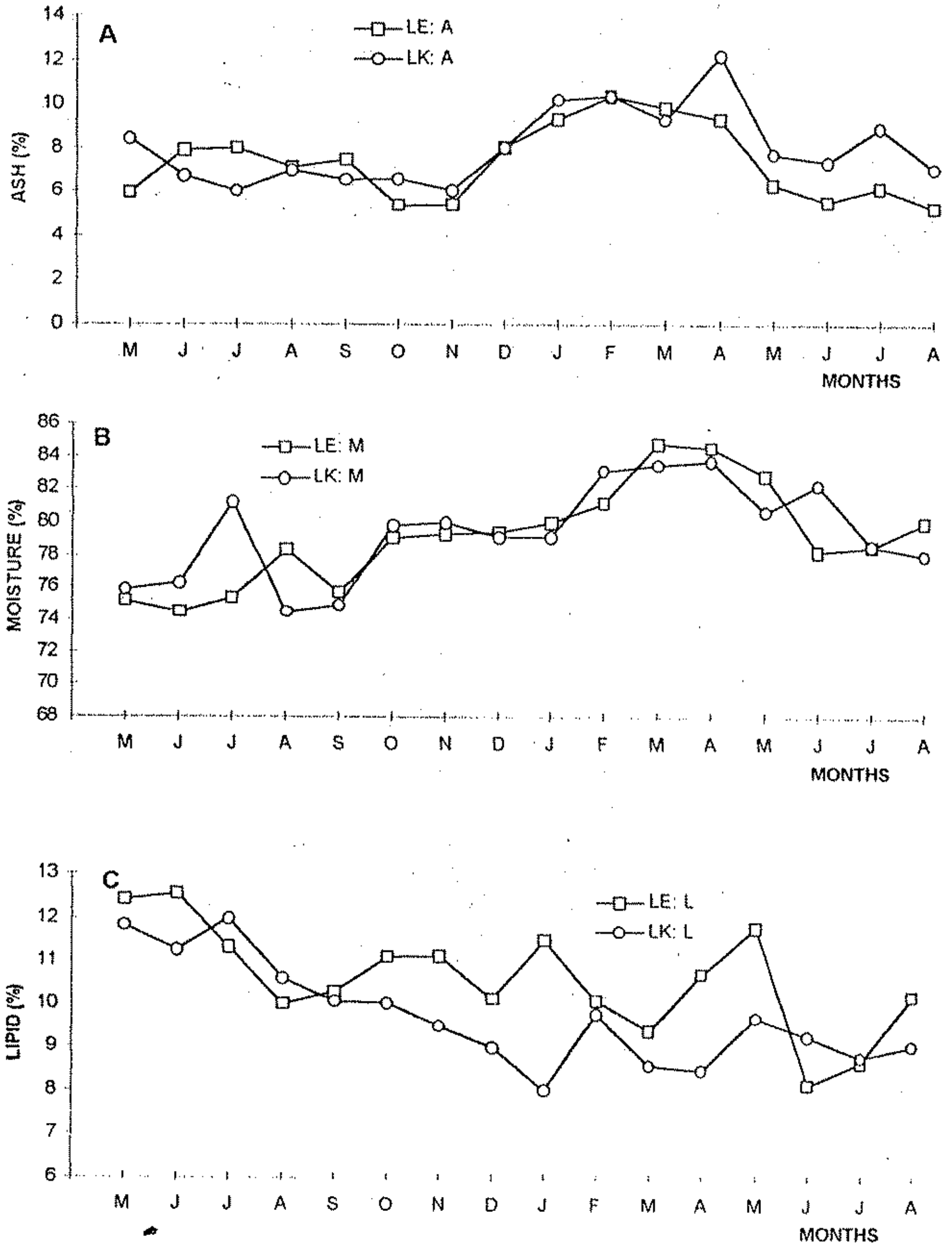


Figure 2 Monthly distribution of wet meat volumetric condition index (CIV) (A), dry weight condition index (CID) (B) and meat yield (MY) (C) of mussels in Loch Etive (LE) and Loch Kishorn (LK).


A
LE: A
LK: A
ASH (%)
14
12
10
8
6
4
2
0
M J J A S O N D J F M A M J J A
MONTHS
B
LE: M
LK: M
MOISTURE (%)
86
84
82
80
78
76
74
72
70
68
M J J A S O N D J F M A M J J A
MONTHS
C
LE: L
LK: L
LIPID (%)
13
12
11
10
9
8
7
6
M J J A S O N D J F M A M J J A
MONTHS

in salinity between the sampling period depending on the freshwater run-off from rivers and surrounding mountains to the loch ($P<0.05$). However, very little variation in salinity was observed between the two depts and between the sampling periods ($P>0.05$). The lowest saliniy values were recorded with a mean of 7.5 ‰ at 2 in Loch Etive, in April and with a minimum of 30 ‰ in Loch Kishorn. Salinity had a maximum of 28 ‰ at 6 m in Loch Etive in October and of 36.1 ‰ in Loch Kishorn in September.

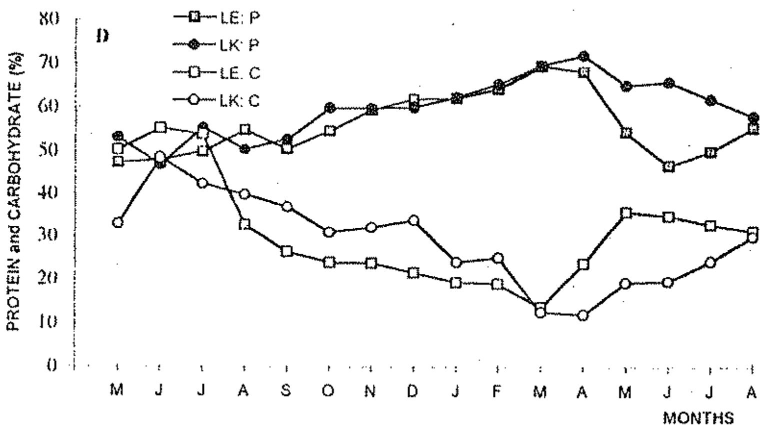


Figure 3 Monthly distribution of ash (A), moisture (B), lipid (C) and protein and carbohydrate (D) in Loch Etive (LE) and Loch Kishorn (LK). A: ash, M: moisture, L: lipid, P: protein and C: carbohydrate.

Chlorophyll-a (Ch-a) value was mainly affected by algal bloom. At both sites and depths the seasonal cycle of Ch-a disributions followed very similar patterns ($P>0.05$). Ch-a values were higher in spring and summer and low to almost absent values in winter. Ch-a content started to decline in August and reached a minimum 0.04 µm/l in November in LK and 0.02 µm/l in February LE. A steady increase commenced at both sites in March-April and reached maximum values of 8.03 µm/l at 6 m in LK and 8.64 µm/l in LE. Seston value was found to be significantly higher in LK than LE ($P<0.05$). It was mainly affected by cycle of phytoplankton and non-living material of terrestial origin. Seston had a minimum value of 1.2 and 1.3 mg/l in December in LK and LE respectively, while maximum values were recorded 8.5 mg/l in June and 15.2 mg/l in May in LE and LK respectively. POM was found to be higher in the spring and the summer months compared with the winter period. Neither site nor depth had a significant effect on POM ($P>0.05$). Mainly POM and POM% was affected algal bloom and large amount of non-living material of terrestial origin. Seston, POM and Ch-a had a peak at the same time in May 1994 in Loch Kishorn and there was a positive relationship between seston and Ch-a ($P<0.05$), and seston and POM ($P<0.05$) while seston had a peak one month after Ch-a in Loch Etive. Transparency ranged from 3.5 to 8.5 m in LE and 4.5 to 10.5 m in LK. It was mainly affacted by phytoplankton bloom and weather conditions.

Condition Index

Monthly distribution of condition indices and meat yield at 2 m and 6 m are shown in Fig 2. The interaction between mussel size, condition indices, meat yield and environmental factors are shown in Tables 3 and 4. Condition indices (CI) and meat yield (MY) had a similar pattern at the two depths. CI was slightly higher at 2 m than 6 m at both experiment sites but these differences were not significant ($P>0.05$). However CI was shown to be different between the sites ($P<0.05$) and it was recorded higher in Loch Kishorn (LK) than Loch Etive (LE). Mean wet meat volume condition index (CIV) was found to be 42.37±1.69% at 2 m and 41.36±1.23% at 6 m in LE while it was 58.03±2.28% at 2 m and 56.03±2.2% at 6 m in LK. Mean dry meat weight condition index (CID) was recorded as 10.21±0.64% at 2 m and 9.57±0.58% at 6 m in LE and 12.82±0.7% at 2 m and 12.53±0.73% in LK. Meat yield was

also found higher in LK than LE. Meat yield was recorded as 33.92±1.38% in LE and 44.19±1.58% in LK. Quick recovery occurred in condition index and meat yield after spawning and which took place more than once in a year in Scottish sea lochs. Time of the peak in the condition index and meat yield variable year to year depending environmental factors.

Condition indices and meat yield were significantly affected by temperature, salinity, accumulation and release of reproductive materials as well as the utilization of stored energy resources during the winter months.

Biochemical composition

Monthly distribution of biochemical compositions are shown in Fig. 3 and correlation matrix in Tables 3 and 4 for both sites. The mean values of biochemical composition is given in Table 2. The energy content of mussels were similar in LE (5.33±0.03 kcal/g) and LK (5.3±0.05 kcal/g) ($P>0.05$). The monthly value of energy ranged from 5.15 to 5.59 kcal/g in LE while it ranged from 4.98 to 5.68 kcal/g in LK.

There was no significant differences in biochemical composition between the sites ($P>0.05$). Lipid level was found to be higher in LE compare to LK, although the difference was not significant ($P>0.05$). There was no clear seasonal pattern in lipid values but they mainly fell rapidly after spawning and then increased again as the gametes matured. There was a good agreement between carbohydrate and annual condition index which reflects the interaction between food availability, temperature, salinity and reproductive cycle. Carbohydrate had a positive relationship with lipid ($P<0.05$) while it was related inversely with protein ($P<0.001$). Minimum carbohydrate values were recorded immediately after spawning but just before spawning protein had a maximum value. After spawning, carbohydrate recovered very quickly and protein decreased. In general, the moisture values were at a minimum during the summer while increasing steadily to maximum in March and April, coinciding with the time of minimum carbohydrate, meat weights and maximum protein. Carbohydrate was found more abundant in summer than winter and there was a change over during the winter from carbohydrate to protein as the main energy reserve in both lochs.

Discussion

Condition indices and meat yield cultured mussels are clearly related to the storage and release of gonads. These results agree with Dolah *et al.*, (1992). The condition indices and meat yield of mussels exhibited similar pattern at 2 m and 6 m at both sites. Condition indices were found to be higher in Loch Kishorn (LK) than Loch Etive (LE) and were mainly affected by temperature and salinity. Quick recovery occurred in condition indices after spawning which took place more than once a year. The peak in spawning is changeable year to year depending on environmental factors in a particular area. When food is available, condition indices increase with combination of temperature and salinity. Mason and Drinkwater (1981) suggested that autumn and winter are the best time for marketing cultured mussels from Scotland while Okumus (1993) reported that mussels are suitable for marketing during May-

Table 1. Mean (±SE) of monthly values of environmental parameters measured at 2 and 6 m at each experimental site from May 1993 to August 1994. Superscript letters are indicate one-way ANOVA comparition between the sites at P<0.05 or less.

Site		Temperature (C)	Salinity (%o)	Seston (mgl^{-1})	POM (mgl^{-1})	POM%	Ch-a (μg^{-1})	Particle Number	Transparency (m)
	2m	11.12±1.03	20.57±1.36	3.13±0.46	1.67±0.18	44.76±3.06	1.81±0.47		
LE	6m	11.02±0.96	22.68±1.18	2.93±0.41	1.41±0.14	43.13±3.06	1.81±0.54		
	Mean	$11.07±0.97^a$	$21.63±1.28^a$	$3.03±0.43^a$	$1.54±0.16^a$	$43.94±2.98^a$	$1.81±0.50^a$	$40098±2411^a$	$5.25±0.32^a$
	2m	11.07±0.90	33.27±0.36	4.76±0.88	1.86±0.24	56.68±2.78	1.76±0.44		
LK	6m	11.06±0.81	33.79±0.25	4.91±0.90	1.80±0.21	51.91±2.65	1.68±0.50		
	Mean	$11.07±0.84^a$	$33.53±0.31^b$	$4.83±0.88^b$	$1.83±0.23^a$	$54.30±2.84^a$	$1.73±0.47^a$	$43761±4338^b$	$7.31±0.50^b$

Table 2. Minimum, maximum and mean (±SE) values of biochemical composition (in dry meat %) in Loch Etive (LE) and Loch Kishorn (LK).

		Lipid	Protein	Carbohydrate	Moisture	Ash
	Min.	8.16	46.81	13.74	74.42	5.28
LE	Max.	12.53	69.57	55.19	84.77	10.43
	Mean	10.60±0.31	56.16±1.85	31.16±3.14	79.17±0.78	7.36±0.43
	Min.	8.01	46.95	12.08	74.43	6.11
LK	Max.	11.82	71.97	48.59	83.42	12.22
	Mean	9.74±0.30	59.99±1.73	29.07±2.58	79.39±0.74	8.05±0.44

Table 3. *Mytilus edulis*. Correlation matrix between environmental factors, condition indices and biochemical composition in LE.: CIV, condition index volumetric; CID, condition index dry; CH, chlorophyll-a; SES, seston; POM, particulate organic matter; T, temperature; S, salinity; MY, meat yield; L, lipid; P, protein; C, carbohydrate; A, ash; M, moisture; Le, lenth of mussel in the Loch Etive. Significance levels: *: $P \leq 0.05$; **: $P \leq 0.01$; ***: $P \leq 0.001$

	CIV	CID	CH	SES	POM	T	S	MY	L	P	C	A	M	E
CID	0.815***													
CH	0.208	-0.018												
SES	0.244	0.208	0.547*											
POM	0.218	0.078	0.672**	0.932***										
T	0.895***	0.663**	0.211	0.057	0.060									
S	0.965***	0.832***	0.152	0.310	0.264	0.747***								
MY	0.508*	0.687**	0.249	0.596*	0.477	0.325	0.560*							
L	0.241	0.370	0.238	-0.141	-0.071	0.081	0.304	0.240						
P	-0.812***	-0.779***	-0.389	-0.455	-0.387	-0.751***	-0.762***	-0.638**	-0.116					
C	0.657**	0.703**	0.492	0.349	0.328	0.606*	0.611*	0.600*	0.451	-0.787***				
A	-0.773***	-0.587*	-0.344	-0.420	-0.398	-0.691**	-0.740**	-0.591*	0.012	0.658**	-0.345			
M	-0.768***	-0.873***	0.045	-0.084	-0.005	-0.683**	-0.752***	-0.497*	-0.288	0.830***	-0.721**	0.375		
E	-0.673**	-0.663**	0.235	0.150	0.252	-0.719**	-0.595*	-0.334	-0.010	0.608*	-0.476	0.351	0.758***	
Le	-0.390	-0.540*	-0.088	-0.046	-0.073	-0.286	-0.414	-0.426	-0.689**	0.389	-0.689**	-0.054	0.644**	0.319

Table 4. *Mytilus edulis*. Correlation matrix between environmental factors, condition indices and biochemical composition in the Loch Kishorn. LK, Loch Kishorn (Supercripts are given in Table 3)

	CIV	CID	CH	SES	POM	T	S	MY	L	P	C	A	M	E
CID	0.707**													
CH	0.435	0.181												
SES	0.310	-0.092	0.841***											
POM	0.305	-0.070	0.792***	0.940***										
T	0.689**	0.692**	0.204	-0.098	0.015									
S	0.411	0.578*	0.097	0.093	0.108	0.546*								
MY	0.963***	0.686**	0.453	0.274	0.322	0.697**	0.327							
L	0.664**	0.628**	0.349	0.132	0.184	0.670**	0.596*	0.745***						
P	-0.578*	-0.912***	-0.041	0.306	0.227	-0.740**	-0.507*	-0.636**	-0.729**					
C	0.554*	0.786***	-0.040	-0.381	-0.321	0.721**	0.432	0.625**	0.737**	-0.947***				
A	-0.650**	-0.671**	-0.124	0.076	0.072	-0.792***	-0.497*	-0.614*	-0.555*	0.673**	-0.699**			
M	-0.355	-0.881***	-0.037	0.308	0.247	-0.576*	-0.471	-0.359	-0.443	0.877***	-0.715**	0.500*		
E	-0.338	-0.530*	-0.143	0.000	-0.008	-0.247	-0.258	-0.251	0.059	0.351	-0.245	0.210	0.517*	
Le	-0.314	0.456	-0.122	0.053	-0.082	-0.366	-0.374	-0.491	-0.841***	0.647**	-0.641**	0.266	0.402	-0.204

December in Loch Etive and Dunstaffnage Bay (on the west coast of Scotland). In the present study, harvesting of mussels in Loch Etive and Loch Kishorn should stop in March-April and July-August which are the spawning and recovery periods. The remaining time mussel harvesting may be maintained. However, these periods are changeable depending on environmental factors (such as food, temperature, salinity etc.) in a particular area of west coast of Scotland. In the light of these results meat yield of mussels might be most practical measure of condition and health of mussels for the mussel industry. Austin *et al.*, (1993) suggested that seasonal fluctuations in condition index could be explained by changes in salinity and temperature. However, Small and Stralen (1990) reported that mussel condition correlates strongly with average annual primary productivity and but not chlorophyll-a concentration. During the winter there is a long period of sexual activity and gonad development does not begin until spring and during the reproductive period abundant food is available so that growth and gametogenessis can take place at the same time (Williams, 1969). Sastry (1968) showed that post spawning of *Argopecten irridians* required an abundant food

suply and explosure to minimums threshold temperatures for initiation of growth and gametogenessis. Decline in gonadal index probably due to nutritional stress resulted in some resorption of ripe gametes (Martinez *et al.*, 1992). Bayne *et al.*, (1978) reported that a simultaneous regression and resoption of previously formed gametes occurred in *Mytilus edulis* under temperature stress or a lack of food.

Abbe *et al.*, (1988) declared that high values in condition index in oyster generally indicate that they are in good physiological condition, but low values do not necessarily indicate oyster in poor health because condition decreases whenever tissue is lost; spawning therefore results in a short term loss in condition. Long term loss, however, may indicate stress from other sources such as pollutants, hypoxia or disease.

Chipperfield (1953) reported that ripening of gonads takes place within a few weeks of the onset of spawning, in general commencing when the sea temperature has risen above 7°C; there is no correlation between nutritional condition and ripening of gonads or subsequent spawning. Lauckner (1983) suggested that a reduction in condition of several bivalve species associated with parasitism with the indication that parasites stress their host, affecting wide variety of biochemical physiological functions.

Rajas and Ruiz (1972) and Walne (1970) found a significant relationship between condition index and glycogen content in oysters. Taylor *et al.*, (1992) reported that carbohydrate followed same seasonal trend as condition index in *Mytilus edulis*. These results are in agreement with the present study where carbohydrate correlated significantly with condition index. Condition index is cheangeable depending on mussels size and year to year (Baird, 1966) with a peak in February which agrees with the present study in Loch Kishorn.

Carbohydrate was more abundant in summer than winter and there was a change over during winter from carbohydrate to protein as the main energy reserve in the both sites. Lipid is a source of energy and is used principally in gametogenessis and loss during spawning. When mussel spawn their lipid levels fall and increase again with gonadal development.

Özet

Etive ve Kishorn göllerinde çevresel factörlerin etkisi; tuzluluk, sıcaklık, seston (askıdaki toplam madde), organik madde, klorofil-a'nın sal sisteminde yetiştirilen midyelerin (*Mytilus edulis*) kondüsyon faktörü ve biyokimyasal özellikleri üzerine Mayıs 1993'ten Ağustos 1994'e kadar çalışıldı. Kondüsyon indeksleri: yaş et volumetrik kondüsyon indeks (CIV) ve kuru et ağırlık kondüsyon indeks (CID) ve et verimi (MY) her iki koyda 2m ve 6m derinliklerde benzerlik göstermiştir. Sırasıyla Etive gölünde ve Kishorn gölünde CIV %41.81 ve %57.15 bulunurken CID %9.77 ve %12.54 olarak tespit edilmiştir. Kishorn gölündeki midyelerin kondüsyon indeksi Etive gölündekinden fazla bulunmuştur ($P<0.05$) fakat her iki gölde derinliğin etkisi önemsiz bulunmuştur. Başlıca midyelerin kondüsyonu Etive gölünde sıcaklık ve tuzluluktan etkilenmiştir. Bununla birlikte Kishorn gölünde sıcaklığın etkisi önemli olmuştur.

Ortalama protein Kishorn gölünde %59.99±1.73 ve Etive gölünde %56.13±1.85 olarak bulunmuş iken sırasıyla ortalama karbonhidrat %29.07±2.58 ve %31.16±3.14 olarak tespit edilmiştir. Karbonhidrat ile protein ters ilişki göstermiştir. Yağ %9.74±0.3 ve %10.6±0.31 iken sırasıyla Kishorn gölünde ve Etive gölünde kül oranı %8.05±0.44 ve %7.36±0.43 olarak elde dilmiştir. Ortalama nem oranı Etive gölünde %79.39±0.74 ve Kishorn gölünde %79.17±0.78 olarak bulunmuştur. Karbonhidrat ile yağ pozitif ilişki gösterirken protein ve yağ ters orantılı bir ilişki göstermiştir. Her iki gölde nem ve kül oranları pozitif ilişki gösterirken karbonhidrat ve yağ ile negatif bir ilişki arzetmiştir.

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