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FISHING, PROCESSING, AND MARKETING OF THE JELLYFISH, *Aurelia aurita* (L.), FROM SOUTHERN BRITISH COLUMBIA

by

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ABSTRACT

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The jellyfish, *Aurelia aurita* (L.), occurs in easily-harvested summer concentrations in coastal British Columbia waters. A short review of the biology of this extremely wide-spread, temperate species is provided. *A. aurita* intrinsically has a low protein content, 4 to 6% of lyophilized dry weight, which yields a low quality product after various dehydration procedures using salt and alum. A test-marketed product was produced at a price ($\approx\$7.0 \cdot Kg^{-1}$) within the cost range of commercial samples of imported (rhizostome) jellyfish, but failed to interest local Asian consumer groups. *A. aurita* does not appear able to support a viable fishery at this time in British Columbia. An overview of the Asian rhizostome jellyfish fishery and details on various commercial processing methods are included.

RÉSUMÉ

Sloan, N. A. and C. R. Gunn. 1985. Fishing, processing, and marketing of the jellyfish, *Aurelia aurita* (L.), from southern British Columbia. Can. Ind. Rep. *Fish. Aquat. Sci.* 157: 29 p.

Dans les eaux côtières de la Colombie-Britannique, on rencontre pendant l'été en concentrations facilement exploitables la méduse *Aurelia aurita* (L.). On passe brièvement en revue la biologie de cette espèce des régions tempérées, qui est extrêmement répandue. *A. aurita*, intrinsèquement, a une faible teneur en protéines, représentant de 4 à 6% de poids sec lyophilisé, et fournit un produit de qualité inférieure après divers procédés de déshydratation au moyen de sel et d'alun. On a préparé un produit qu'on a mis sur le marché à titre d'essai à un prix ($7.0/kg) se situant dans l'échelle des coûts d'échantillons commerciaux de méduse importée (rhizostome), mais on n'a pas réussi à intéresser les groupes de consommateurs asaitiques locaux. *A. aurita* ne semble pas pouvoir faire l'objet d'une pêche rentable en Colombie-Britannique pour le moment. On donne également un aperçu de la pêche du rhyzostome asiatique et des détails sur les diverses méthodes de transformation commerciale.

INTRODUCTION

For many years the occurrence of summer swarms of the jellyfish, *Aurelia aurita* (L.), in southern British Columbia waters has interested biologists (Fraser 1942). *A. aurita* is a coelenterate (Class Scyphozoa, Order Semaeostomeae, Family Ulmaridae) and thus, a close relative of corals and sea anemones. They have a saucer-shaped 'bell' or 'umbrella' fringed with numerous fine marginal tentacles. The mouth is at the under surface of the umbrella and has four long oral arms or 'lobes' as illustrated in Figure 1. Certain nearshore areas predictably have *Aurelia* swarms each summer. Do these large, accessable aggregations constitute a fishery resource which can be processed and marketed for the local Asian market or export to Japan?

Japanese processors have been interested in sources of *Aurelia aurita*, a cosmopolitan temperate water species (Møller 1980a). *A. aurita* are much smaller and less firm-bodied than rhizostome jellyfish which are fished in warmer waters. The biology of *A. aurita* is thoroughly reported from Europe (Møller 1980a, b), Japan (Yasuda 1969, 1973), and to a lesser extent in the northeast Pacific. The life cycle of *A. aurita* (Fig. 1) is well known and usually lasts a year although overwintering ephyrae (Henroth and Grøndahl 1983) and adult medusae (Hamner and Jensen 1974; Møller 1980b) occur. Adult medusae are abundant (often occurring in swarms) in summer (Lid 1979) followed by decreasing abundance into the autumn (Shenker 1984), degeneration and die-off after spawning in late autumn-early winter (Møller 1980a, b). Growth is very rapid in the summer as juveniles approach breeding size (Hamner & Jensen; Møller 1980b) whilst feeding on zooplankton and larval fish (Møller 1980a; Bailey and Batty 1983).

From the scientific literature one could speculate that late summer harvesting of pre-spawned adults, may be best for product quality as body size would be at its maximum. Surface-water fishing around dusk may be the most efficient as *A. aurita* congregate near the surface at this time (Yasuda 1973). This is due to active upward swimming during the day, followed by downward migration at night (Mackie et al. 1981).

We report here on summer fishing, processing, and marketing of *A. aurita* from southern British Columbia. Fishing methods and landings, processing techniques and difficulties, and problems of marketing the processed jellyfish locally are discussed.

OVERVIEW OF THE PRESENT WORLD JELLYFISH FISHERY

The world jellyfish fishery, with an approximate annual value of U.S. $40-50 million, occurs mainly for export to Japan (Omori 1978, 1981; Sloan 1986) and to a lesser extent Singapore, Hong Kong, and Taiwan

(Soonthonvipat 1976). There are at least five commercially exploited jellyfish species, all large, firm-bodied, and from warm waters (Class Scyphozoa, Order Rhizostomeae, Family Rhizostomatidae). Recent world landings indicate Thailand and China have been the biggest producers (Table 1). Landings averaged approximately 60,000 t annually between 1975 and 1979 before declining in 1980, and then increasing to over 84,000 t in 1982. This small boat, dip-net fishery is highly seasonal and occurs close to shore.

Jellyfish are processed with salt and alum to decrease the 96-98% water content to about 60-65%. The product, whose major edible component is collagenous connective tissue protein (Kimura et al. 1983), is marketed for such purposes as soup-making. Price varies according to species, quality, and size. The dried product is finely sliced, washed several times to remove the salt, and boiled. In Thailand and other Southeast Asian countries jellyfish is not served as a main course but with other food items as hors-d'oeuvre or appetizer. Jellyfish is now very popular in Chinese restaurants throughout southeast Asia (Soonthonvipat 1976).

The rhizostome fishery has been poorly studied; stock sizes are unknown and little resource management is exercised. Moreover, their biology is not well known and their taxonomy is in disarray (Omori 1981). Harvesting occurs in summer and early autumn in northern latitudes (south Japan) and earlier in the year in more southern latitudes (Malaysia) (Omori 1981). Monsoon winds strongly influence the seasonality of harvesting on southern grounds.

Rhizostome jellyfish feed on zooplankton (Phillips et al. 1969); and growth must be extremely rapid, for their large body size is reached with in their one-year life cycle (Omori 1981). Interannual catch fluctuations can be great, perhaps reflecting either variations in currents or wide oscillations in stock size. Jellyfish are usually transported in currents far from their spawning site (Uchida 1954).

The main harvested species is *Rhopilema esculentum* (Japanese: 'bizen-kurage'), which reaches a 50 cm bell diameter and a weight of 30-50 kg (Omori 1981). There is a traditional June to October fishery for *R. esculentum* along the South Korea, China and southwest Japan coasts and a larger, recently established April to October fishery for *R. esculentum*, *R. hispidum*, *Lobonema smithi* and *Mastigias* sp. in Thailand, Indonesia, and Malaysia (S. Chaitiamvong pers. comm.).

There are also cooler water, more northerly commercial rhizostome species such as *Stomolophus nomurai*, found in the Sea of Japan (Uchida 1954). According to Omori (1978) *S. nomurai* occasionally occurs in late summer-early autumn "swarms" that, as in other rhizostomes, may relate to spawning (Hamner and Haure 1981). *S. nomurai* can have a bell diameter of 1 m and weight greater than 100 kg (Omori 1978).

A more detailed account of the world fishery is available in Sloan (1986).

FISHING METHODS AND RESULTS

Between August 15 and November 8, 1984, 11 dip-net and 2 seine fishing cruises were made in Trevenen Bay and Okeover Inlet in the northern Strait of Georgia (Fig. 2). Dip-netting was completed by a crew of three from an 8 m vessel. On calm days the vessel drifted through Aurelia swarms with dip-nets, one on each side of the boat, deployed across the vessel's direction. Dip-net tracts and seine sites are illustrated in Figure 3A, B. In low Aurelia concentrations the vessel moved slowly in reverse and jellyfish accumulated on the dip-nets. The catch was scooped into buckets. The dip-nets had 1.5 m handles with 19 mm stretch mesh secured taut across their 73 x 86 cm hoops. A 37 m long by 9 m deep seine (19 mm stretch mesh) was used on two occasions in Trevenen Bay (Fig. 3A). The seine was deployed around a swarm and the catch dip-netted into onboard containers. The fishing times, weather conditions and surface sea water temperatures were recorded on all cruises.

Table 2 lists the dip-netting and seining activities which yielded approximately 2820 kg of Aurelia aurita . The weather was usually clear and sunny and the surface water temperature varied between 13.5 to 15.0°C. Fishing effort averaged only 3.6 h per cruise. Mean dip-net CPUE (kg jellyfish$\cdot h^{-1}$) was 35.9 ± 17.7 (S.D.) compared to 210.0 ± 42.2 (S.D.) for seining. CPUE of dip-netted jellyfish was not related to time of day of fishing (Fig. 4A) but did increase steadily as the fishing season progressed (Fig. 4B).

PROCESSING METHODS AND RESULTS

Aurelia aurita were processed by methods developed for rhizostome jellyfish, i.e. treatment in various concentrated solutions of salt/alum mix while attempting to keep the pH between 3.5 to 4.6. We used Potassium Alum [potassium aluminum sulphate: $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\ H_2O$] which is a white, odourless double salt available in granular form and readily soluble in water. The salting process is intended to dehydrate and preserve jellyfish without denaturing its collagenous connective tissue protein which imparts a desirable firmness to the final product. Jellyfish collagen is very sensitive to temperature and readily melts (Rigby and Hafey 1972), therefore heating is not involved in the processing stage. The umbrella of A. aurita, ≈92.4% of the body weight, contained 97.2% moisture; the entire body was 97.4% moisture (J. N. C. Whyte pers. comm.). Advice on processing from Japanese buyers was contradictory, so a number of methods were used and the product from each method evaluated.

The first eight batches were processed using the Nakasho Shoten Co. protocol (Appendix I) and results are listed in Table 3. Poorly constituted product occurred from most batches and jellyfish with attached oral arms spoiled more rapidly than those without.

The second processing occurred at the D.F.O. Fisheries Technology Laboratory, Vancouver where the protocol of Tanikawa (1971) was used (Appendix II). Jellyfish were stored overnight in sea water during which time most voided their gonads. Oral arms were retained on jellyfish in batches 9a and 9b and removed from those in batches 9c and 9d. Approximately 1 kg of good product was obtained from 10 kg jellyfish (batches 9a and 9c). The presence of attached oral arms did not decrease product quality.

A third processing protocal supplied by the Tokyo Moruchi Shoji Co. was then used (Appendix III). This was a detailed 6-step process in which jellyfish were subjected to solutions of increasing salinity and decreasing alum content while maintaining pH in the region of 4.0 (Table 5). All samples were successfully processed into acceptable (well constituted) product. It is important to note that processed jellyfish should not be stored with any alum in the salt (J. N. C. Whyte pers. comm.).

Appendix IV contains two Thai jellyfish processing techniques not used here, but included for reference (S. Chaitiamvong pers. comm.).

It is vital to product quality that the collagenous connective tissue protein is maintained during the dehydration induced by salting. We estimated the protein content of live and processed A. aurita and commercial rhizostome jellyfish product. Samples were thoroughly washed, homogenized, lyophilized (freeze-dried) and the dry weight then recorded. Hydrolysis of the dried samples was achieved by soaking in 1.0 N NaOH for 1 h at 45°C. Protein content was determined by the method of Lowry et al. (1951) and verified by independent analysis for total nitrogen using the Kjeldahl method (Hawk et al. 1951).

The protein content of lyophylized live A. aurita was low (4-6%) (Table 6). The protein content of air-dried, processed A. aurelia was significantly lower (<3.0%) than processed rhyzostome jellyfish (45.3 to 84.6%). Lyophilized rhizostome product yielded high (95-100%) protein values compared to those of lyophilized A. aurita product (0.14-1.5%; Table 6).

TEST MARKETING METHODS AND RESULTS

Retail prices of salted jellyfish can range from \$4.62 to \$25.55 $\cdot kg^{-1}$ in Vancouver, B.C. (Table 7). With this in mind and an estimated necessary selling price for British Columbia A. aurelia at \$7.06 per kg (Table 8), local test marketing was attempted.

During January and February, 1985, packages of salted A. aurita were prepared for test marketing in Vancouver. Examples were given to Chinese fish wholesalers and to owners of Japanese and Chinese restaurants and their comments were invited.

The results were conclusive from the Japanese restaurants; the taste and texture, mainly the lack of a "crunch", made dried A. aurita unsuitable.

Dried jellyfish is used in Chinese cooking in a different way and is prepared in a plum sauce mix. The preparation of this dish requires washing and quickly blanching shredded dried jellyfish then mixing in plum sauce once the jellyfish have cooled. In Vancouver, restaurants prepare their own jellyfish in plum sauce. The quality and likely price of dried A. aurita did not satisfy restaurant owners as an attractive substitute for imported jellyfish.

High priced, high quality jellyfish preparations are available in Japan, e.g. jellyfish with sea urchin roe (uni). While no attempt was made to see if A. aurita could be prepared in this way, the low levels of protein present in dried A. aurelia did not make it a likely species of choice.

DISCUSSION

Aurelia aurita are available in large numbers during summer 'swarms' and are easily fished from small boats with simple equipment in sheltered British Columbia coastal waters. Little harvesting effort was necessary to obtain sufficient quantities for test processing. The summer abundance of A. aurita is probably a predictable local phenomenon. Thus, the availability of stocks is not a potential 'bottleneck' for a British Columbia jellyfish fishery.

Processing Aurelia into a marketable product was unsuccessful. The amount of collagenous connective tissue protein, essential to product quality, was naturally low and further decreased, for unknown reasons, by several different processing protocols.

Test-marketed product was produced at a price within the cost range of imported market samples of rhizostome jellyfish in Vancouver, but failed to interest local Asian consumer groups.

The intrinsic low protein content of A. aurita, and resulting poor product quality, is considered the 'bottleneck' to a profitable jellyfish fishery in British Columbia waters.

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Table 1. World rhizostome jellyfish landings according to country from FAO Yearbooks of Fisheries Statistics (Anonymous 1983, 1984).

	% world landings according to year				
Country	1978	1979	1980	1981	1982
Thailand	91.8	78.1	17.6	56.2	65.2
China	5.4	18.5	73.4	35.2	24.3[2]
Indonesia	2.8	3.4	4.1	4.7	4.8
Philippines	0.0	0.0	4.9	3.9	0.2
Malaysia	0.0	0.0	0.0	0.0	5.5
Total[1] (t)	68158	70314	12261	51272	84605[2]

[1]Metric tonnes live weight

[2]Indicated as a preliminary estimate by FAO.

Table 2. Test fishing conditions, catch and effort for <u>Aurelia aurita</u> between August and November, 1984.

Date	Sample number	Catch (kg)	Gear	Fishing effort (h)	CUPE ($kg \cdot h^{-1}$)	Time of day	Weather conditions	Water temp. (°C) at 2 m depth
08/15	1	30	Dip-net	2	15	14:30-15:30	clear	15.0
08/16	2	70	Dip-net	4	17.5	14:00-16:00	clear	15.0
08/17	3	100	Dip-net	4	25	08:00-10:00	clear	15.0
08/17	4	50	Dip-net	2	25	16:00-17:00	clear	15.0
08/17	5	50	Dip-net	2	25	17:00-18:00	clear	15.0
09/04	6	120	Dip-net	4	30	11:00-13:00	overcast	14.5
09/11	7	240	Dip-net	6	40	10:30-13:30	clear to overcast	14.5
09/13	8	250	Dip-net	6	42	09:30-12:30	clear	14.0
09/20	9	200	Dip-net	4	50	10:00-12:00	clear	14.0
09/30	10	300	Dip-net	4	75	14:00-16:00	overcast	14.0
10/09	11	150	Dip-net	3	50	10:30-11:30	clear	14.0
10/24	12	540	Seine	3	180	10:15-13:15	rain, no wind	14.0
11/08	13	720	Seine	3	240	09:30-12:30	overcast	13.5

Table 3. Results of processing *Aurelia aurita* by using the Nakasho Shoten* protocol.

Date	Sample number	Quantity (kg) processed	Post-harvest treatment	Days between saltings 1st-2nd	Days between saltings 2nd-3rd**	Comments
08/15	1	30	Held overnight, oral arms and gonads retained	N. D.		spoiled, rejected
08/16	2	70	Held overnight, oral arms and gonads removed	N. D.		spoiled, rejected
08/17	3	100	Held overnight, after oral arms and gonads removed	13	12	satisfactory product
08/17	4	50	Held overnight, oral arms and gonads retained	N. D.		satisfactory product
08/17	5	50	Held overnight after oral arms and gonads removed	17	8	satisfactory product, used more first-salting mix
09/10	6***	120	Processed immediately	8	N. D.	spoiled, rejected***
09/11	7***	240	Processed immediately, oral arms and gonads retained. 1:15 first salting to live weight ratio	7	N. D.	spoiled, rejected***
09/13	8***	250	Processed immediately after removal or oral arms and gonads. 1:15 first salting to live weight ratio	6	N. D.	spoiled, rejected***

*See Appendix I for details of protocol

**Third salting includes 'fourth' salting of the protocol in Appendix I

***Product rejected because pH went above 4.6, causing spoilage

N.D. = no data

Table 4. Results of processing A. aurita by from using the Tanikawa (1971) protocol* at the Fisheries Technology Laboratory, Vancouver.

Date	Sample number	Quantity (kg) processed	Initial brine to jellyfish ratio	First salting Salt:Alum	Second salting Salt:Alum	Third salting Salt:Alum	Final Yield (kg)	Comments
09/20	9a	10	1:5	10:1	20:1	40:1	1.0	good product
09/20	9b	10	1:5	10:0v53	100:1	1000:1	0.8	poor product
09/20	9c	10	1:5	10:1	20:1	40:1	1.1	good product
09/20	9d	10	1:5	10:0v53	100:1	1000:1	0.9	fair product

*See Appendix II for details of protocol.

Table 5. Results of processing *A. aurita* by using the Tokyo Maurichi Shoji protocol*.

Date	Sample number	Quantity (kg) processed	Post-harvest treatment	Days between salting 1st-2nd	Days between salting 2nd-3rd	Comments
09/30	10a	60	Held for 24 h	2	4	good product
09/30	10b	60	Held in sea water for 24 h - large vol.	2	4	good product
09/30	10c	60	Held in sea water for 24 h - low vol.	2	4	good product
10/21	11	150	Held in sea water for 24 h, arms removed, washed in fresh water.	5	7	good product
10/24	12	540	Held in sea water for 24 h arms removed, washed in fresh water.	7	7	good product
11/08	13a	60	(as above) large jellyfish.	6	6	good product
	13b	180	(as above) small jellyfish.	6	6	good product
	13c	120	(as above) mixed jellyfish.	6	6	good product

*See Appendix III for details of protocol.

Table 6. Protein content of live and processed _Aurelia aurita_ and market samples.of processed rhizostome jellyfish product.

Sample	No.		% protein
Live _A. aurita_		(live weight 30 g)	4.0-6.0*
		(live weight 40 g)	4.0-6.0*
A. aurita	3	(processed by Nakasho Shoten protocol)	2.8**
	4	"	2.1**
	5	"	3.0**
A. aurita	9a	(processed by Tanikawa (1971) protocol)	0.9**
	9b	"	0.7**
	9c	"	0.5**
	9d	"	0.5**
A. aurita	10a	(processed by Tokyo Maruchi Shoji protocol)	0.4**
	10b	"	0.4**
	10c	"	0.4**
	11	"	0.3**
	12	"	0.4**
	13a	"	0.2**
	13b	"	0.2**
	13c	"	0.3**
A. aurita	?	(6 samples from the 3 protocols)	0.14-1.50*
Market samples of rhizostome jellyfish from Vancouver			
'Cock' Brand 1			48.8**
'Cock' Brand 2			45.3**
Falcon			50.5**
HYK			55.2**
Kaneku			64.3**
Yoshikawa			84.6**
Market sample (brand unknown)			95-100*

*Percentage protein based on lyophilized (freeze-dried) dry weight.

**Percentage protein based on _air_ dry weight only - a large amount of water was undoubtedly present and contritubutes to the apparently low values.

Table 7. Retail cost of jellyfish products purchased in Vancouver (March, 1984).

Product origin firm; city; country	Brand name	Salted product type	Price ($Can.) per kg
Thai World Import and Export Co., Ltd., 1004/38 Rachadapisek Road Bangkok, Thailand	Cock	Whole medusae	$ 6.49*
	"	Sliced "	6.82*
Yuen Kee Hong, 13-15 Queen's Road West, 5th Floor, Hong Kong	?	Whole small medusae	4.62*
Mei Heong Yuen, Singapore	Falcon (Malaysian)	Whole medusae	7.88*
Yoshikawa Shoji Co., Ltd. Yokohama, Japan 231	Marufuji	Finely sliced	25.55**
	Kaneku	" "	24.12**

* Marketed in 454 g bags.

** Marketed in 70 g bags.

Table 8. Cost estimates for harvesting, processing, and marketing 300 kg of processed *Aurelia aurita* from 2000 kg live weight of catch.

		Estimated $ Can.
Fishing costs (yield of 2000 kg)		
Labor costs @ $10.00 per hour		$120.00
Vessel, net, etc.		200.00
Total		$320.00
Processing costs (yield of 330 kg)		
Labour* @ $6.00 per hour		$250.00
Processing materials	460.0 kg salt @ $0.31 per kg	143.00
	33.3 kg alum @ $3.30 per kg	110.00
Plant overhead		125.00
Total		$628.00
Total (fishing and processing)		$948.00
Recovery is estimated at 8%:	160 kg product recovered @ $948.00, i.e. 1 kg of product costs	$5.92
Marketing and packaging (per kg product)		0.25
Profit (at 15%)		0.89
Required wholesale selling price (per kg)		$7.06

*Labour rates assume that oral arms would NOT be removed.

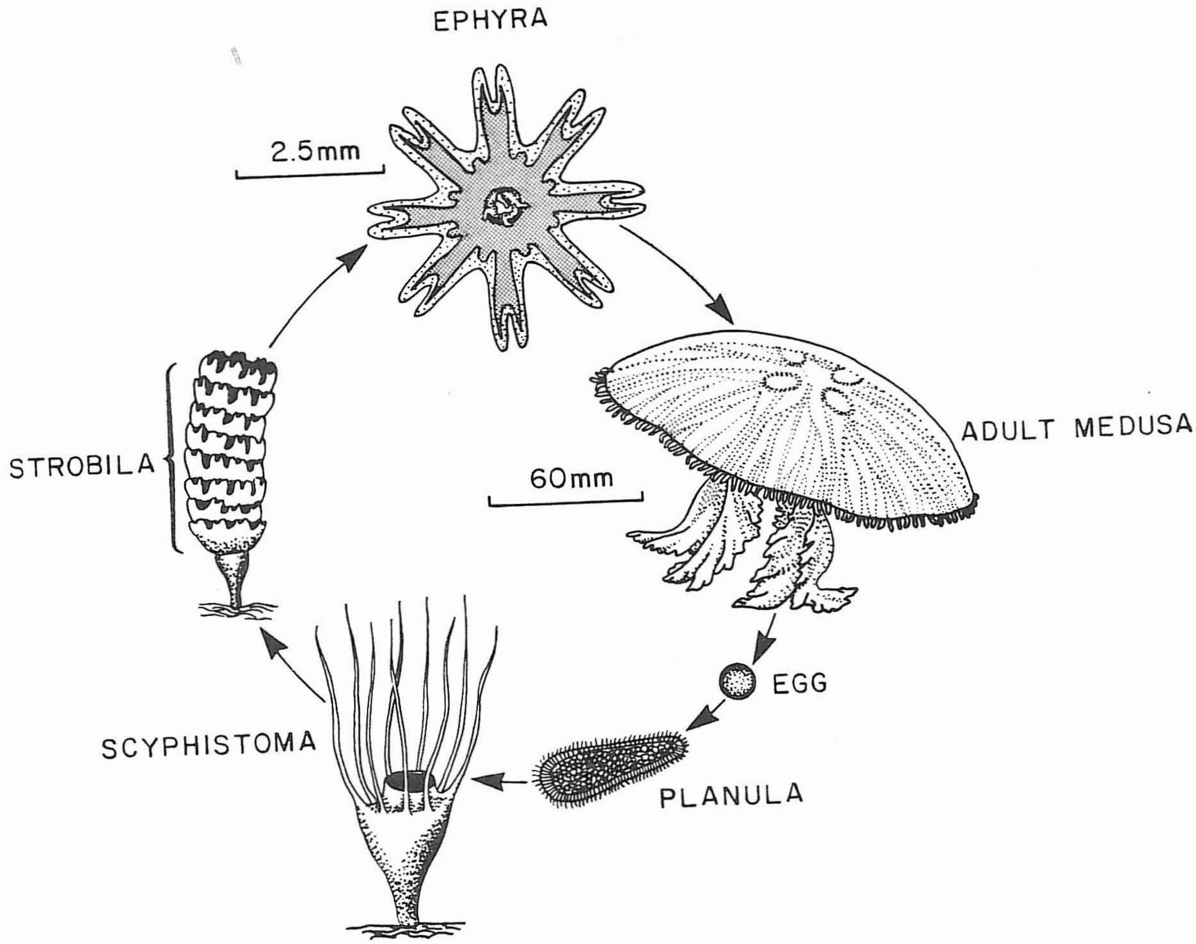

Fig. 1. Life history of Aurelia aurita (after Barnes 1980). Fertilized eggs develop in the oral arms and eventually emerge as motile 'planula' larvae. These larvae settle, change form, and bud off (or strobilate) tiny juvenile medusae called 'ephyrae', which soon change into miniatures of the adult medusae and grow very rapidly to full adult size of ≈150 mm umbrella diameter.

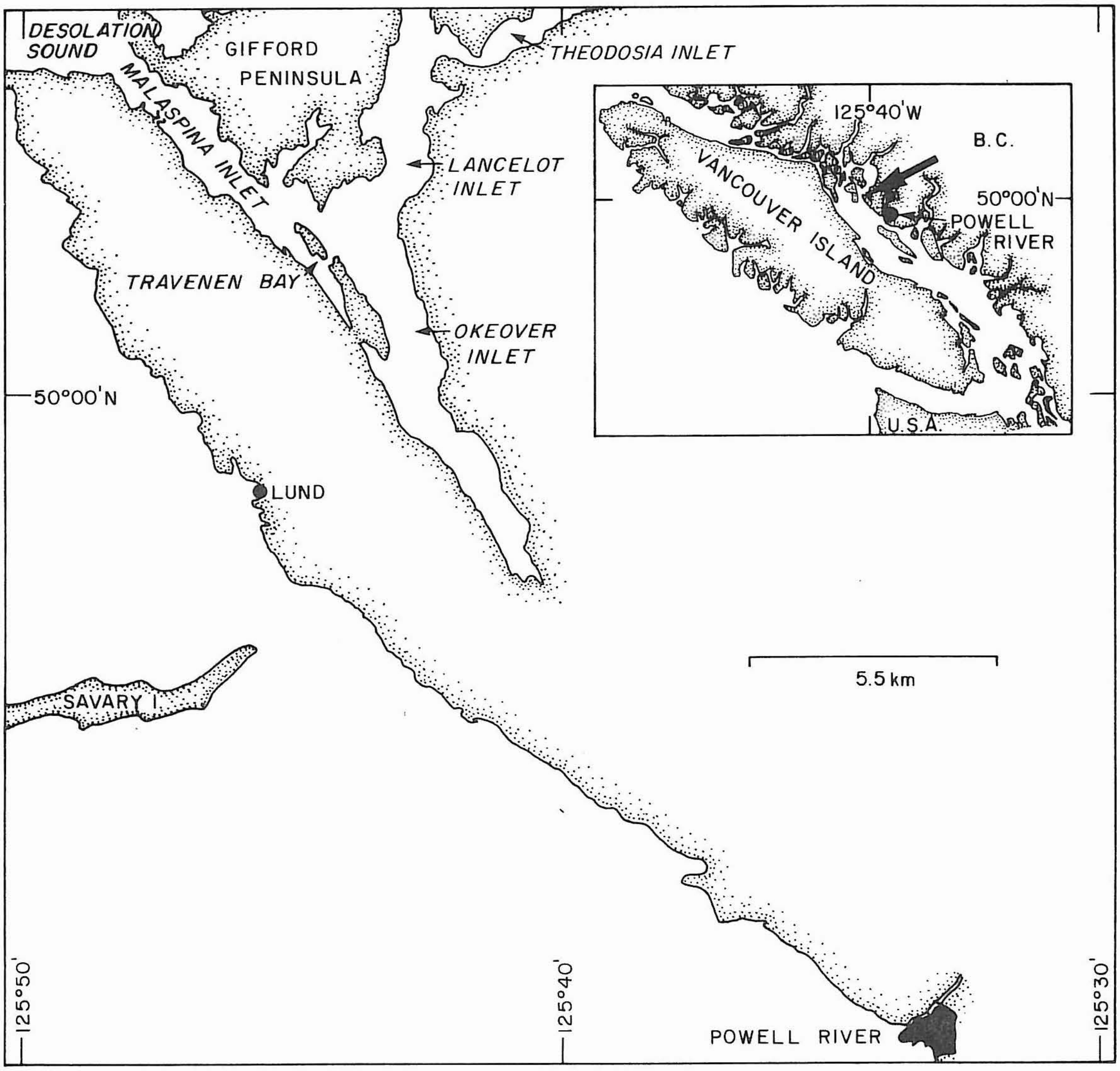

Fig. 2. Map of the inlets north of Powell River and Lund in which the fishery occurred. Trevenen Bay and Okeover Inlet are connected to open water (Desolation Sound) via Malaspina Inlet.

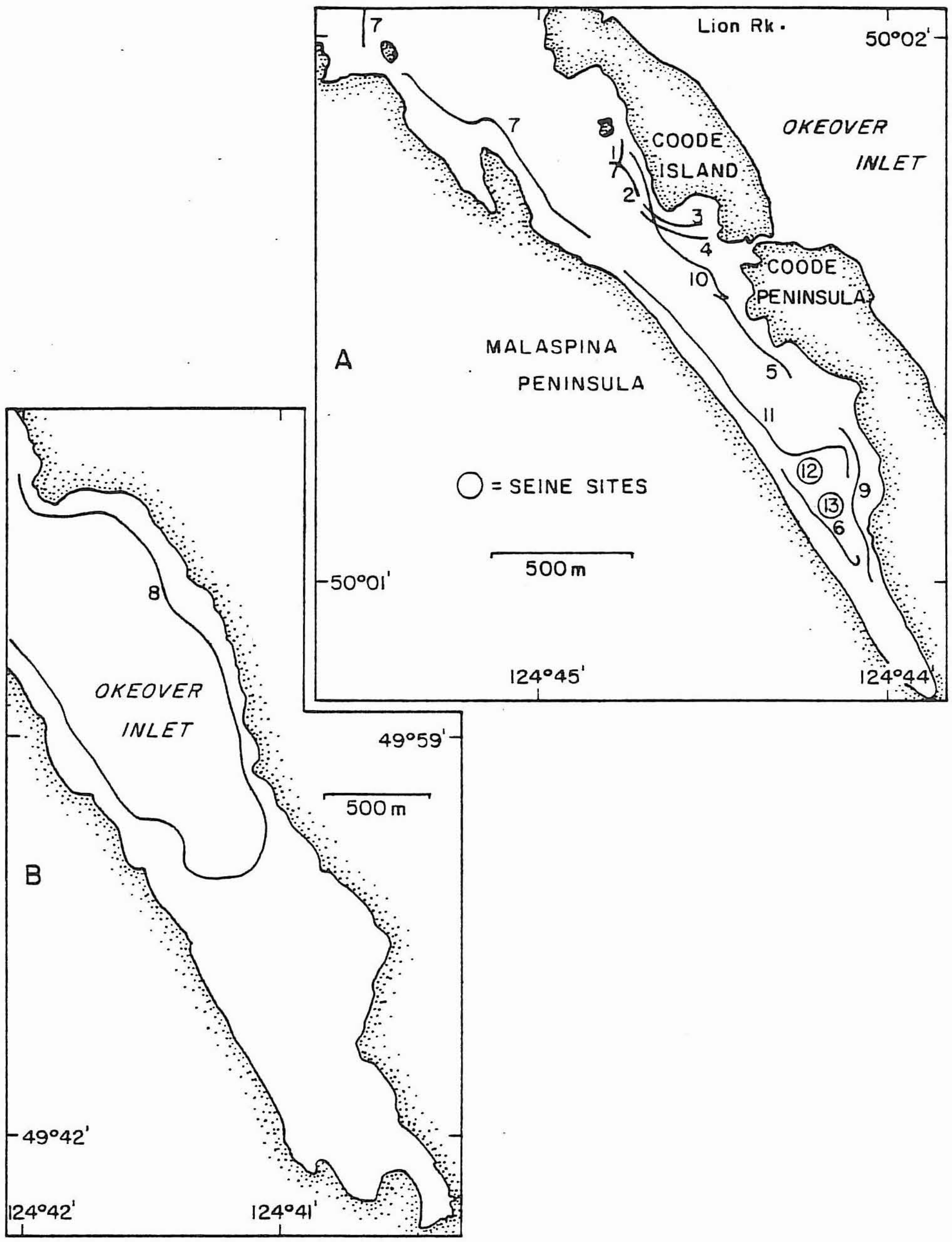

Fig. 3. Maps of the fishing locations. A: Trevenen Bay with dip-net tracts (1 to 7; 9 to 11) and seine sites 12 and 13. B: Okeover Inlet with dip-net tract 8.

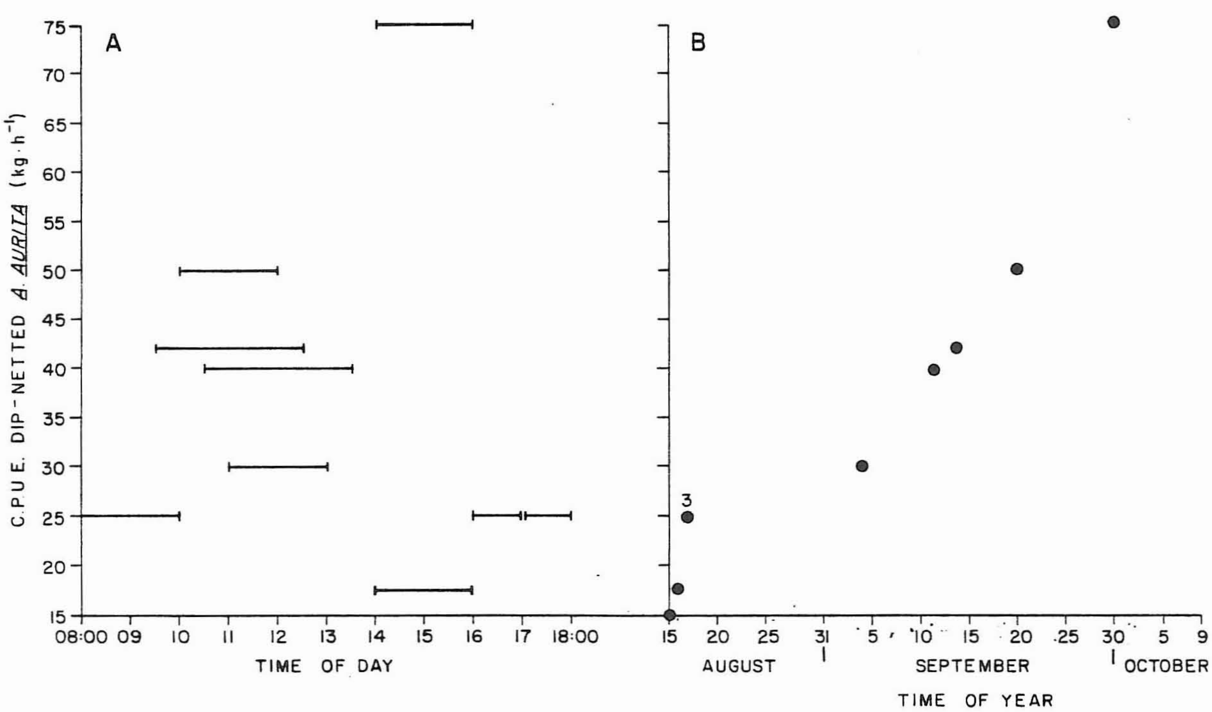

Fig. 4. Catch per unit effort (C.P.U.E.) of dip-netted A. aurita in kg per hour of fishing according to time of day (A) and time of year (B).

Appendix I. System for processing salted jellyfish from Nakasho Shoten Co., Ltd., Kashima City, Japan.

I. Washing and first salting.

Wash jellyfish in fresh (?) water. Layer jellyfish in containers with complete immersion in a solution of 1 part salt + alum* to 10 parts fresh (?) water for 4-7 days. The surface membrane of the umbrella is sometimes removed.

II. Second salting.

Drain away the solution**. Soak first-salted product in a 1:20 solution for 4-7 days.

III. Third salting.

Drain away solution**. Soak second-salted product in a 1:40 solution for 4-7 days.

IV. Fourth salting.

Wash product*** in strong brine (no alum?) solution prior to packaging in robust plastic bags.

Points of caution:
*No ratio of salt to alum was provided and no recommendation on pH given.
**No mention of recycling solutions was made.
***Final product will have lost >70% of its original water content.

Appendix II. System for processing salted jellyfish from Tanikawa (1971) which was used at the Fisheries Technology Laboratory, Vancouver.

I. Soaking and first salting.

Soak in sea cold water for 8-10 h to remove mucus. Drain and rub into surfacE of jellyfish a salt:alum (14 kg: 75 g) mixture equivilent to ≈20% of the weight of the jellyfish being salted. Store in a barrel for ≈2 to 3 days.

II. Washing, final salting and storage.

Wash and drain the first-salted jellyfish. Pack jellyfish in barrels with 20% less salt/alum* mixture, compared to the amount of jellyfish, than the first salting.

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*alum should probably not be used with the salt for product storage (J. N. C. Whyte, pers. comm.).

Appendix III. System for processing salted jellyfish from Tokyo Maruichi Shoji Co., Ltd., Tokyo, Japan.

I. Dressing and first salting.

Only the umbrella is salted so the tentacles (oral arms), intestines, and gonads are removed. The umbrella is flattened and its edges can be trimmed. This dressed product must be salted within 6 hours of capture. For every kilo of dressed product the following solution (pH=4) will be used for a 24 h salting period:

Sea water	1.0 l
Alum	40.0 g
Lime	2.0 g
Bleaching power	0.7 g

The solution is discarded after one use.

II. Second salting.

For every kilo of first-salted jellyfish the following solution (pH=4) will be used for a 48 h salting period:

Fresh water	1.0 l
Salt	100.0 g
Alum	20.0 g
Lime	1.0 g
Bleaching powder	0.4 g

The solution is discarded after one use. Product must have lime washed away after this second salting.

III. Third salting.

For every kilo of second-salted jellyfish the following solution (pH=4) will be used for a 96 h salting period:

Fresh water	1.0 l
Salt	150.0 g
Alum	10.0 g

This solution can be filtered and recycled for other third-salting usage.

Appendix III (cont'd)

IV. Fourth salting.

For every kilo of third-salted jellyfish the following solution (pH=4) will be used for a 96 h salting period.

Fresh water	1.0 l
Salt	150.0-180.0 g
Alum	10.0 g

This solution can be filtered and recycled for other fourth-salting usage.

V. Fifth salting.

Soak jellyfish in 100% saturated saline solution for 96 h.

VI. Final process.

Drain jellyfish for 72-96 h, in piles no higher than 30 cm, in a cool place. Thoroughly drained product must be stored at or near 0°C.

Points of caution:

A) The range of pH for solutions must be 3.5 to 4.6. Outside this range the proteins will be denatured. The pH is maintained by using the lime and bleaching powder.

B) Alum is useful both as a disinfectant and for reducing pH. The possibility of impure salt can be monitored by examining pH and salinity.

C) Potassium alum or Na $Al(SO_4)_2$ can be used. The latter must be monitored for pH value. The use of $Al_2 (SO_4)_3(NH_4)_2 SO_4 \cdot 24 H_2O$ is prohibited in Japan.

D) While keeping the pH at 4 the salinity can be gradually increased. Rapid salinity increase, can cause protein damage and two-rapid water loss, which decreases product quality.

Appendix IV. Thai jellyfish processing methods according to Mrs. S. Chaitiamvong (pers. comm.).

In Thailand there are two main jellyfish processing techniques:

1) Using a red astringent solution made from soaking (for 24 to 48 h) bark shavings of Pettophorum enerme. Cleaned whole (small) or partitioned (large) jellyfish are soaked in this solution for 24 h or less (6-12 h) if the solution is concentrated.

2) Processing with salt and potash alum [$KAl(SO_4)_2 \cdot 12H_2O$]. The steps are:

a) - separate umbrella from oral arms.

b) - clean portions with sea water and either rinse in a sea water/alum solution (ratio 100: 5 kg) or sprinkle portions with potash alum powder, leave over night and rinse in the morning.

- the main processing chemicals are NaCl, $KAl(SO_4)_2 \cdot 12H_2O$ and $NaHCO_3$, and they can used in three ratios (100:25:5, 100:10:1 or 100:2:0 by weight).

c) - jellyfish portions from step (b) are placed in layers separated by preservatives, in large containers so that chemicals represent about 15 to 30% of the jellyfish. Leave for 24 to 96 h.

d) - repeat step (c) in another container for 48 to 168 h using preservatives with less $NaHCO_3$ and representing only 13 to 20% of the weight of jellyfish. Processing is now finished.

e) - product is stored in just salt (15 to 20% of the weight of jellyfish) until sold. Separated umbrella or oral arm portions (coated with salt) should be sold in plastic bags.