Keeping Quality of Fresh and Frozen Sand Lance, *Ammodytes* sp.

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Introduction

Sand lance, *Ammodytes* sp., also commonly referred to as sand eels, are elongated, slender, round-bodied fish which resemble small eels (Fig. 1), swim with an undulating motion in large schools, and grow to a maximum length of about 6 inches (Bigelow and Schroeder, 1953). In the western Atlantic Ocean their range extends from about Cape Hatteras to Labrador. These fish are usually found in shoal waters either along the immediate coast or on offshore banks having a sandy bottom. With the aid of their long pointed snout, they occasionally burrow in the sand, hence the name sand eel.

Within recent years there has been an explosion in the numbers of sand lance in the northwest Atlantic (Meyer et al., 1979). It has been suggested that this phenomenon may be associated with the decline in the Atlantic mackerel, *Scomber scombrus*, and Atlantic herring *Clupea harengus*, stocks (Morse, 1982). It was also proposed that the increased abundance on the Grand Banks resulted from the depletion of Atlantic cod, *Gadus morhua*, (Winters, 1983). In 1974, the percentage of sand lance larvae comprising the total winter larval fish population in the Mid-Atlantic Bight, Southern New England area, and Georges Bank was about 50 percent, whereas by 1979 this figure had reached close to 90 percent. During that period, the abundance estimates increased by a factor of 20 times (Sherman et al., 1981). These sand lances purportedly represent a threat to important commercial species such as Atlantic cod, haddock, *Melanogrammus aeglefinus*; herring, etc., in that not only are they preying on their young larval forms, but are also competing with them for available food (Hendrickson, 1979).

There is no directed commercial fishery for sand lance on the U.S. east coast. There is a small limited domestic market for the bait industry and an even smaller ethnic market for human consumption (Smith, 1978). In Europe, particularly Denmark and West Germany, sand lance from the North Sea form the basis of an important industrial fishery where they are reduced to fish meal and oil (Borgstrom, 1962; Kietzmann, 1969).

In 1978, the New England Fishery Development Program sponsored a study to determine the feasibility of catching sand lance off southern New England (Stellwagen Bank) and the results were reported by Smith and Testaverde[1]. The NMFS Northeast

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[1]Smith, R. M., and S. Testaverde. 1978. Development of a day-trawler fishery for sand launce (Ammodytidae) off the coast of New England: Technical and biological considerations. Speech presented at the 23rd Annual Atlantic Fisheries Technological Conference, Williamsburg, Va.

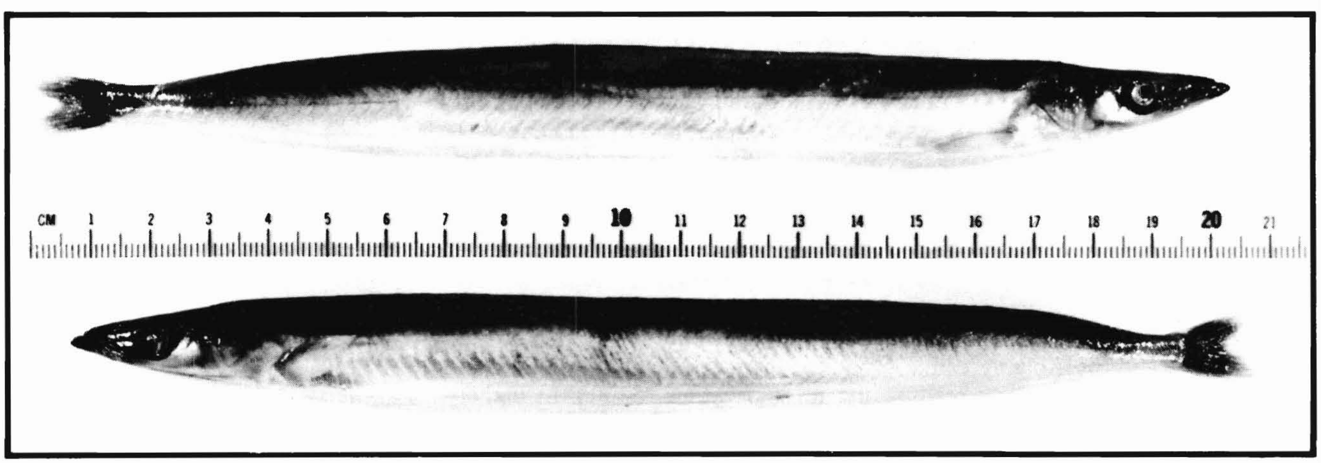

Figure 1. – Sand lance, *Ammodytes* sp., from Stellwagen Bank.

Fisheries Center's Gloucester Laboratory participated in that study by comparing methods of holding the sand lance on board the fishing vessel, and also by determining the species' fresh and frozen storage characteristics with regard to its potential as a human food. This paper reports the results of that investigation.

Materials and Methods

The sand lance were caught on Stellwagen Bank in July by a commercial trawler using a small-mesh net in the cod end. One portion of the catch was immediately iced on board ship in standard wood fish boxes (125-pound capacity) and another portion was placed in an insulated tank containing chilled seawater (CSW) prepared by mixing one part seawater with one part ice. The fish were received at the laboratory the same day they were caught. The iced and boxed fish were placed in a walk-in refrigerator at 34-36°F. The CSW tank was relocated in the pilot plant and connected to a recirculating refrigeration unit set to maintain a water temperature of 32-34°F. After 2 days post-mortem, the fish were removed, iced in conventional boxes, and also stored in the refrigerator.

Periodically, samples from both treatments were assayed for: Aerobic plate count (68°F) using the agar medium of Lee and Pfeifer (1974); peroxide value by an iodine titration procedure (Riemenschneider et al., 1943) on either a chloroform-anhydrous sodium sulfate extract of the flesh (Dyer and Morton, 1956) or a chloroform-methanol extract (Bligh and Dyer, 1959); trimethylamine (TMA) content by a modification of the Dyer picrate method (Tozawa et al., 1971). For a Torrymeter reading (Jason and Richards, 1975), six measurements were made on the lateral line along the entire length and the results averaged. For sensory evaluation, the fish were headed and eviscerated, batter-breaded, and deep fried in corn oil. The cooked product with breading removed was rated for flavor and texture on a scale of 1 to 9 (9 = excellent, 5 = marginal) by 12 laboratory personnel with experience in tasting fish of variable quality. Shelf life was considered to have expired when the sensory score value reached 6.

For the frozen storage study, the 2-day post-mortem fish, either iced or held in CSW, were headed and gutted, batter-breaded, frozen and then either air-packed in 2 mil polyethylene bags or vacuum-packed in bags made from Curlon S-660[2] (nylon-PVDC-surlyn) and then stored at 0°F. Samples from the four different treatments (ice-air, ice vacuum, CSW-air, CSW-vacuum) were periodically examined for organoleptic quality and peroxide value, and for extractable protein nitrogen (EPN) by the procedure of Ravesi and Anderson (1969).

For the proximate analysis, moisture content was determined by drying to constant weight in an air oven at 212°F (100°C). Ash was assayed by incineration in a muffle furnace at 1,022°F (550°C). Lipid content was determined by a methanol-chloroform extraction procedure (Bligh and Dyer, 1959). Nitrogen content obtained by micro-Kjeldahl method was multiplied by 6.25 to obtain protein value. All statistical analyses were performed on a programmed HP-97 calculator.

Results and Discussion

Composition

Sand lance chemical composition is presented in Table 1. With a fat content greater than 5 percent, these fish would have to be classified as fatty. However, the fat content of pelagic fish usually varies seasonally and it is not known whether the fat content determined in this study was minimal, maximal, or average. The species of sand lance we studied was most probably American sand lance, *Ammodytes americanus*. Sidwell et al. (1974) reported a lipid content of 1.5 percent for *Ammodytes lancedatus*, and whether this lower value represents a species or seasonal differences is not known.

[2]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Fresh Study

Sand lance held in CSW generally remained in rigor longer compared with the fish stowed in ice. This may have been due to the more rapid lowering of the body temperature by the CSW. Duration of rigor in fish is a function of both the storage temperature and the time required to equilibrate to that temperature. The appearance of the CSW fish was also slightly better because there was less crushing and the CSW had washed the surface slime off the fish. At the end of the initial 2-day holding period, the chilled seawater had acquired an off odor, probably the result of bacterial growth. During subsequent storage in ice there was not much of an apparent difference between the two treatments except for frequency of burst or blown bellies which was greater among fish initially held in CSW. This condition occurs in fish caught when they have been heavily feeding and their digestive tract contains a high content of proteolytic enzymes which dissolve the belly tissues. In Figure 2, percent burst bellies for the two treatments, determined on randomly selected samples of 40 fish per testing, has been plotted as a function of storage time.

Based upon the appearances of the eyes and odor of the flesh, fish from both treatments were considered to be in very good condition after 5 days and in good condition after 8 days. After 12 days the eyes were slightly cloudy and the flesh had developed an

Table 1.—Chemical composition of sand lance.

	Composition (%)			
Form	Water	Protein	Lipid	Ash
Whole	73.2	17.1	6.9	2.6
Edible portion	75.4	18.3	5.1	2.0

oily, fishy odor which had intensified by the 15th day.

The average flavor scores for the fish prestored in CSW were slightly lower throughout a 15-day storage period compared with the all-iced samples (Fig. 3). A significant flavor difference (5 percent level) based on a *t* test was only observed at the eighth day of testing. End of iced shelf life for both treatments occurred at 14 days. It is believed that the slight downgrading of the flavor scores of the CSW samples was due to an increased degree of rancidity in these fish. The more rapid rate of peroxide accumulation in these samples compared with the all-iced samples supported this opinion (Fig. 4). The CSW fish probably absorbed some salt which is known to accelerate the rate of lipid oxidation.

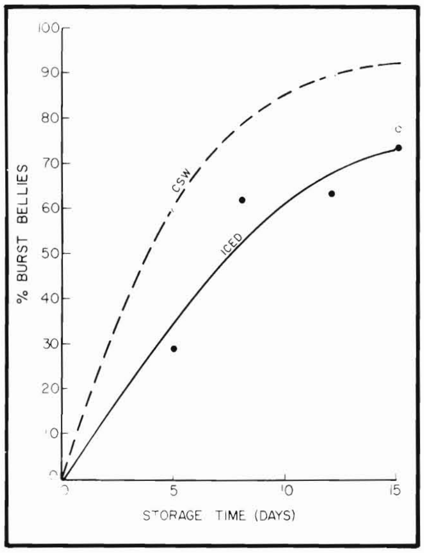

Figure 2.—Effect of stowage method aboard ship on frequency of burst bellies among sand lance held in ice.

The texture of the CSW fish was scored slightly lower throughout storage compared to all-iced fish, because of a softening. However, textural deterioration was not the limiting quality factor governing storage life.

Production of trimethylamine was very similar for both treatments (Fig. 5) and at spoilage the TMA-N content was estimated as 24 mg/100 g. The high correlation coefficient ($r = 0.96$) determined for TMA content and flavor score suggests that TMA content might be a useful spoilage indicator for fresh sand lance.

There was a progressive decrease in average Torrymeter readings during storage, but no significant difference between the two treatments (Fig. 6). In some instances, particularly in the later stage of storage, there was a large variation in readings among the 15 random fish which constituted the sample. At the onset of spoilage the meter reading was estimated from regression analysis as 11-12. With gadoid species we have usually observed a meter reading of 5-7 at incipient spoilage. There was very good correlation ($r = 0.93$) between log meter reading and flavor score. Thus, if used judiciously, this instrument might be employed to assess quality of even small fish such as sand lance.

Frozen Study

Throughout a 50-week storage period at 0°F the ice-vacuum samples showed the best flavor stability (Fig. 7). Frozen storage lives were estimated from regression lines to be: 40 weeks for the ice-vacuum fish; 25 weeks for either the ice-air or CSW-vacuum fish; and 20 weeks for the CSW-air samples. Quality failure was induced by the development of oxidative rancidity which seemed to have been enhanced in samples either packaged in an air atmosphere or initially held in CSW. The peroxide levels reflected the sensory results, that is, the ice-vacuum treatment, which received the highest flavor scores, also contained the least amount of peroxides (Fig. 8). In both the fresh and frozen study, comparative peroxide determinations were made on a chloroform-sodium sulfate

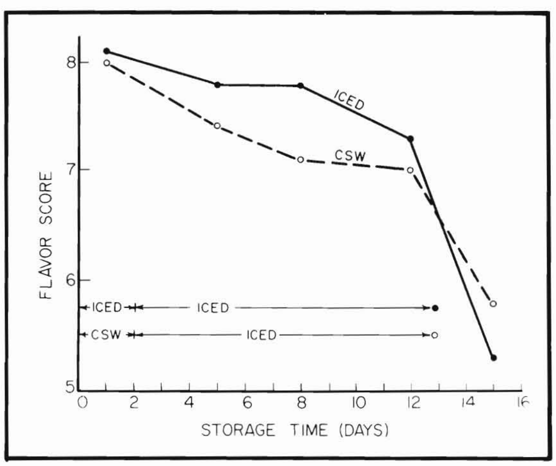

Figure 3.—Effect of shipboard stowage method on flavor score of sand lance held in ice.

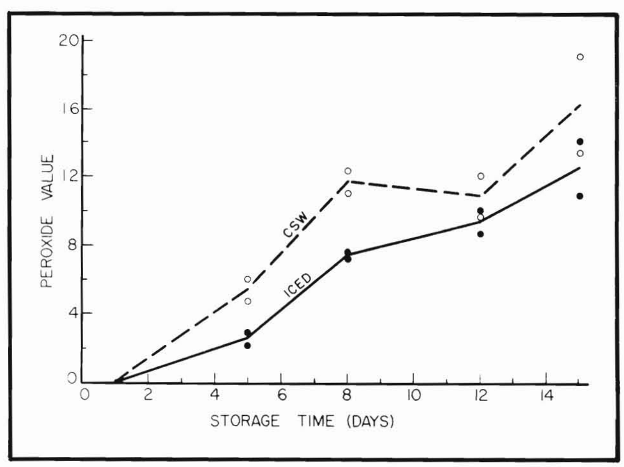

Figure 4.—Effect of stowage method aboard ship on peroxide value of sand lance held in ice.

extract and a Bligh-Dyer chloroform-methanol extract. There was essentially no difference in the result and for future work the chloroform-sodium sulfate method would be recommended because of its simplicity. Takama et al. (1978) also reported the problem of rancidity in frozen sand lance and they were able to suppress the reaction by treatment with a water dispersible tocopherol mixture.

The texture of the sand lance during frozen storage was remarkably stable. Over a 60-week period the average organoleptic texture score had only decreased by 1 point on a 9-point scale and the final rating was "good." Yet, during storage, there was a sharp steady decrease in extractable protein nitrogen (Fig. 9) which would seem to indicate that the proteins were being denatured at a greater rate than indicated by taste tests. It is possible that products of lipid degradation caused denaturation of the sarcoplasmic proteins and this would account for the change in EPN. The ice-vacuum treatment, which showed the least rancidity, also had the lowest loss of EPN. Correlation between sensory texture score and EPN was only fair ($r = 0.64$); however, the EPN value signalling

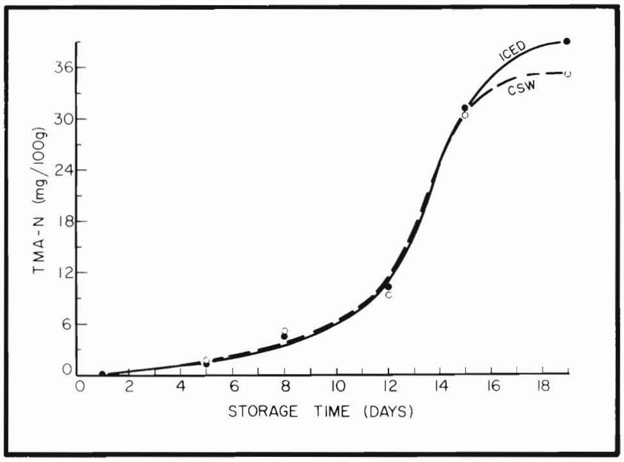

Figure 5.—Effect of shipboard stowage method on trimethylamine content of sand lance held in ice.

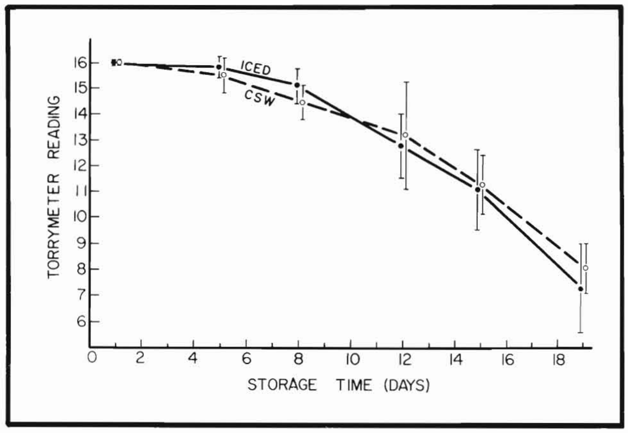

Figure 6.—Effect of shipboard stowage method of Torrymeter readings of sand lance held in ice.

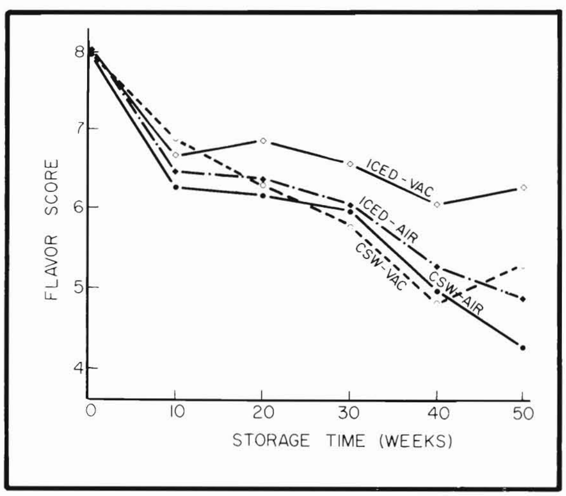

Figure 7.—Flavor score of sand lance treated in various manners and stored at 0°F.

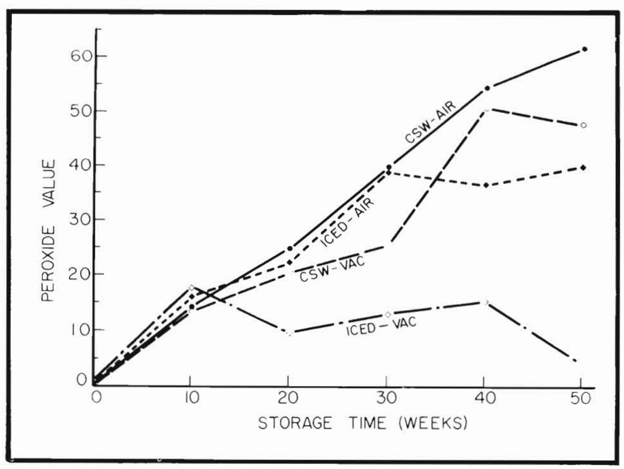

Figure 8.—Peroxide value of sand lance treated in various manners and stored at 0°F.

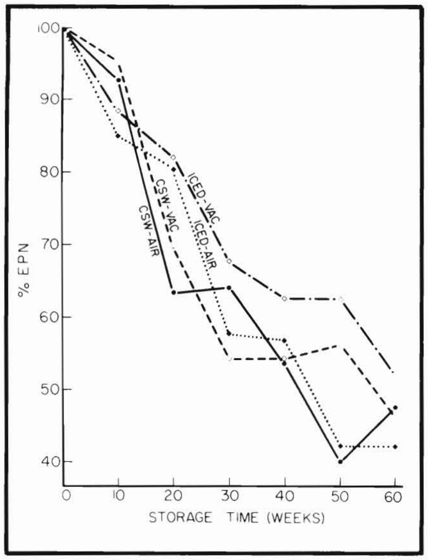

Figure 9.—Extractable protein nitrogen content of sand lance treated in various manners and stored at 0°F.

unacceptable texture was estimated from the regression line as 24. For gadoid species we have usually observed a value of about 30.

Summary

Sand lance have good potential as a food fish. Breaded and fried, their gustatory characteristics are akin to fried smelt. Since sand lance are prone to the development of oxidative rancidity, appropriate protective measures should be taken when long-term storage is anticipated. Although the transport of whole fish in CSW has several advantages, it is not advocated that sand lance be held in this medium beyond 48 hours because of the potential adverse effects on flavor during prolonged frozen storage.

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