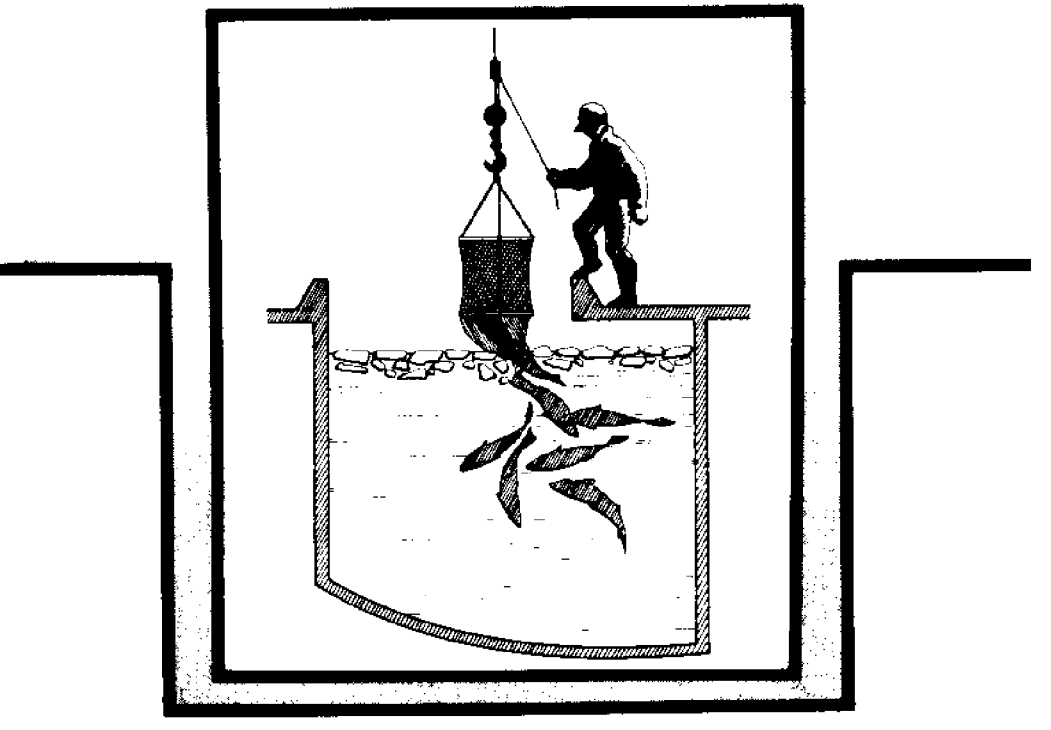
Refrigeration Options for Small Boat Fishermen



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INTRODUCTION

One of the keys to producing good quality fish is immediate chilling. Proper cooling slows bacterial spoilage and enzyme activity, but in order to be effective, it must be done quickly. This requires a good on-board refrigeration system.

Originally, systems such as refrigerated sea water (RSW) and chilled seawater (CSW) were designed and built to chill large volumes of fish, making them ideal for limit seiners and tenders. They were not cost effective or efficient on the smaller vessels such as gillnetters and trollers. With the increased emphasis on product quality and higher prices for chilled fish however, small boat fishermen are finding it necessary to install some type of chilling system aboard their vessels.

Several systems are suitable for small boats. They include: ice, CSW/champagne ice, RSW, chilling coils and burlap.

This bulletin describes various refrigeration/chilling systems, their advantages and disadvantages, and consideration for use aboard small vessels.

ICE

The traditional method for chilling fish in Alaska is with ice. For many small boat fishermen, it is the ideal way to refrigerate the catch (Figure 1) . Ice has many advantages for small vessels due to its tremendous chilling capacity. It can be used successfully in small holds, plastic totes or bare hulls. Ice needs no special equipment and is

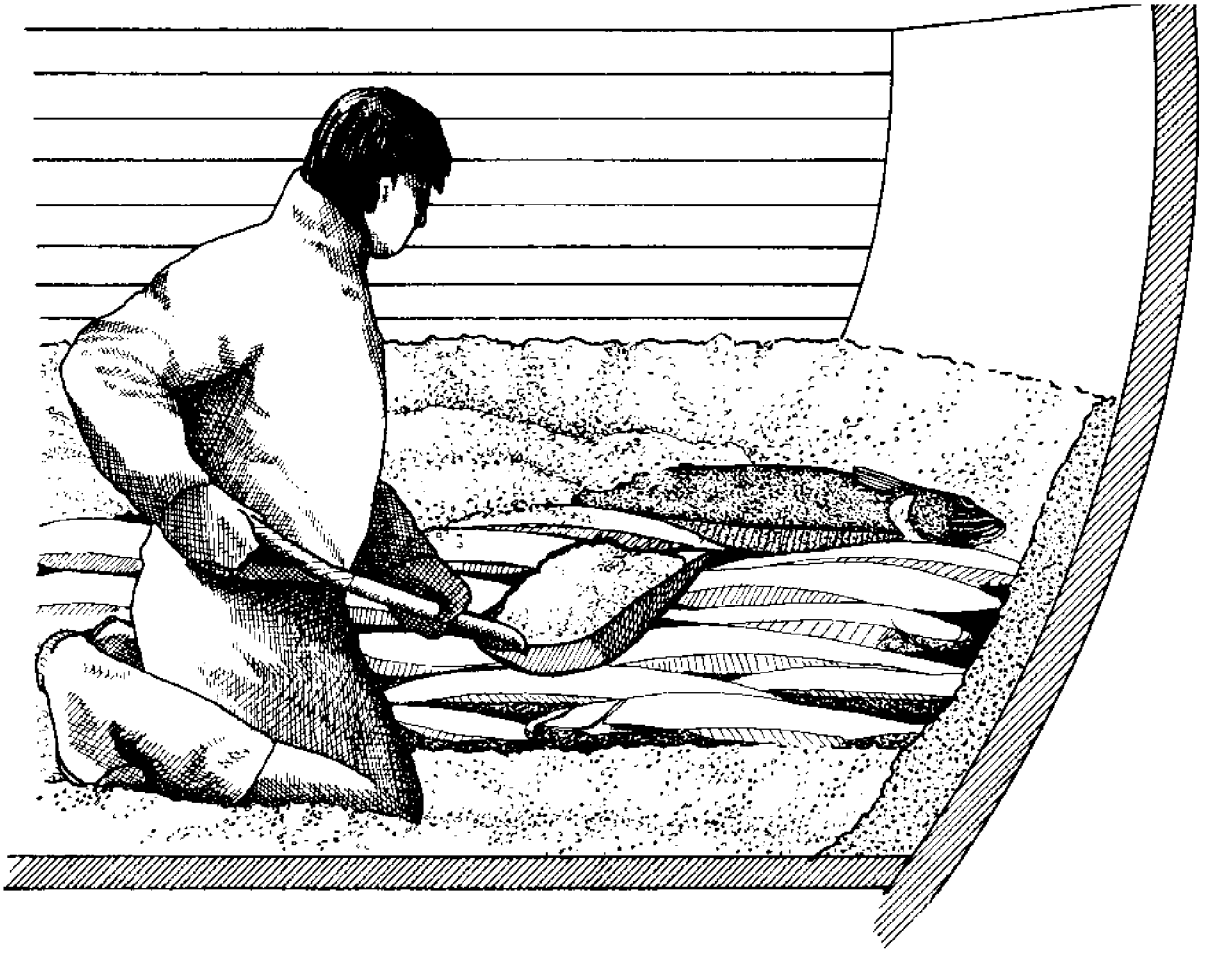

Figure 1. Icing in the hold.

adaptable to any vessel. It has a built-in thermostat so it melts at 32° F-- the ideal temperature for holding fish. There is no opportunity for partial freezing and roe damage. As ice melts, it washes the fish and removes surface slime and bacteria that cause quality loss during storage.

There are some disadvantages to using ice. Without an adequate supply, chilling is less effective, resulting in quality loss. In fisheries such as those of Bristol Bay, limited supplies make ice impractical. Cost can be another consideration, along with labor, since each fish should be handled separately. Considerable time and effort are needed to properly ice fish for best quality.

In choosing ice for chilling, a crucial consideration is its availability and cost. In areas where ice is in short supply during peak periods or where ice supplies are inadequate, it is often necessary to have alternate plans for or sources of ice. And if the fisherman must pay for ice, the cost may not make its use economical. As an example, if ice costs $80 per ton and it requires 1 lb of ice to chill 1 lb of fish, its use adds 4 cents to the cost. This may become an important factor in determining whether ice is a suitable choice.

The amount of ice needed for chilling is another consideration. Theoretically, 1 lb of ice could chill 7 lb of fish from 55° F to 32° F, but under real conditions, much more is needed. This is because other heat sources compete with the fish for the chilling capacity. The more heat that enters the holding system, the more ice needed to chill the fish. Important factors determining ice needs are insulation characteristics

of the holding systems and heat leaks. Heat sources such as engine bulkheads, shaft alleys, and hot weather will dramatically affect the amount of ice needed to chill the catch. Compare the differences between a well-insulated hold and a plastic tote. The insulated hold prevents heat from competing with the fish for chilling while the plastic tote absorbs heat rapidly, requiring additional ice to handle the extra heat as well as chill the fish.

Recommendations for determining amounts of ice needed to chill the catch are 1 lb of ice for 1 lb of fish in poorly-insulated systems, such as totes or bare hulls. For well-insulated holds, 1 lb of ice for every 3 lb of fish is suggested (Figure 2). Space is another consideration Flake ice has a volume of 10 ft^3 per ton. Vessels with small holds may not be able to carry sufficient ice for chilling the fish. In this case, it may be necessary to deliver more frequently, catch less fish or investigate other chilling systems such as chilled seawater.

CHILLED SEAWATER

The chilled seawater (CSW) system is a good option for the small vessel. It is simple and readily adaptable to most boats and containers. Actually, CSW refers to two systems. The older is slush ice: a mixture of ice and seawater. Slush ice has been used by gillnetters and small longline vessels for several years. The newer CSW system is the champagne system. This is a slush ice system incorporating air bubbled through a grid of pipes on the floor of the hold. Perforations in the pipes distribute the air and circulate cold water through the fish (Figure 3). CSW

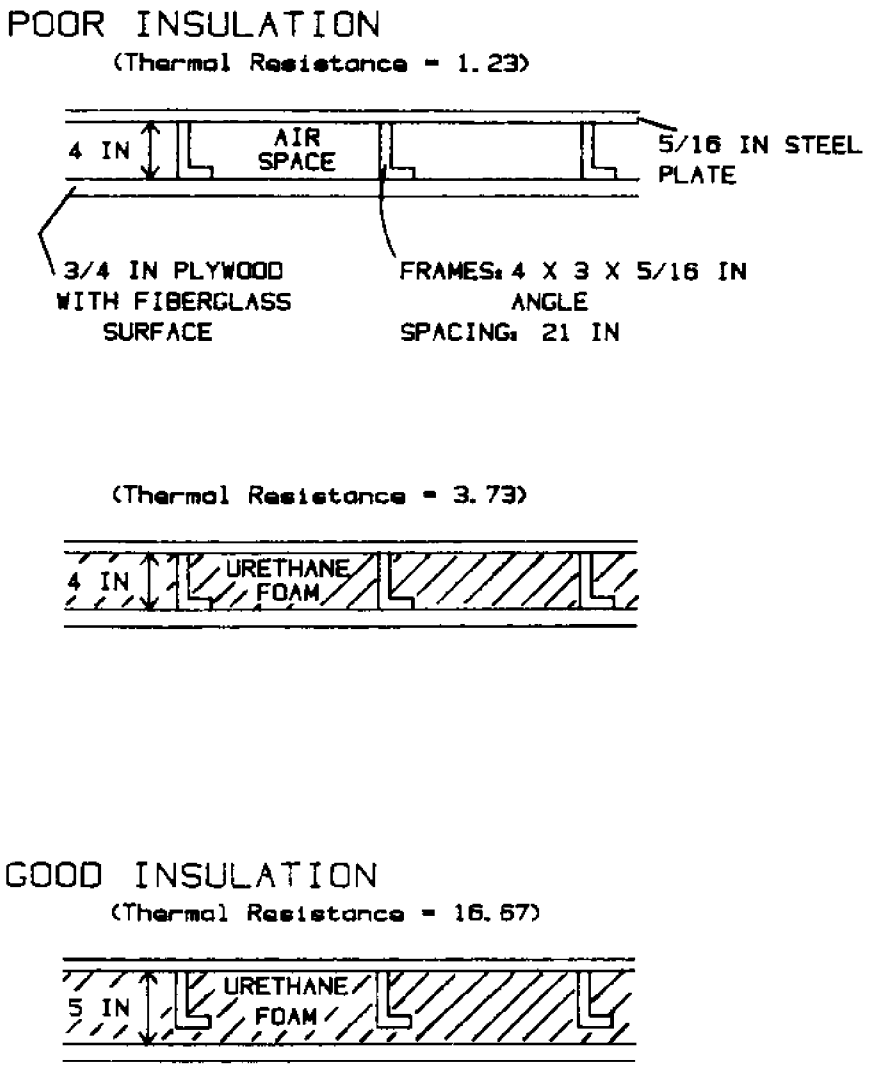

Figure 2. Description of hold insulation.

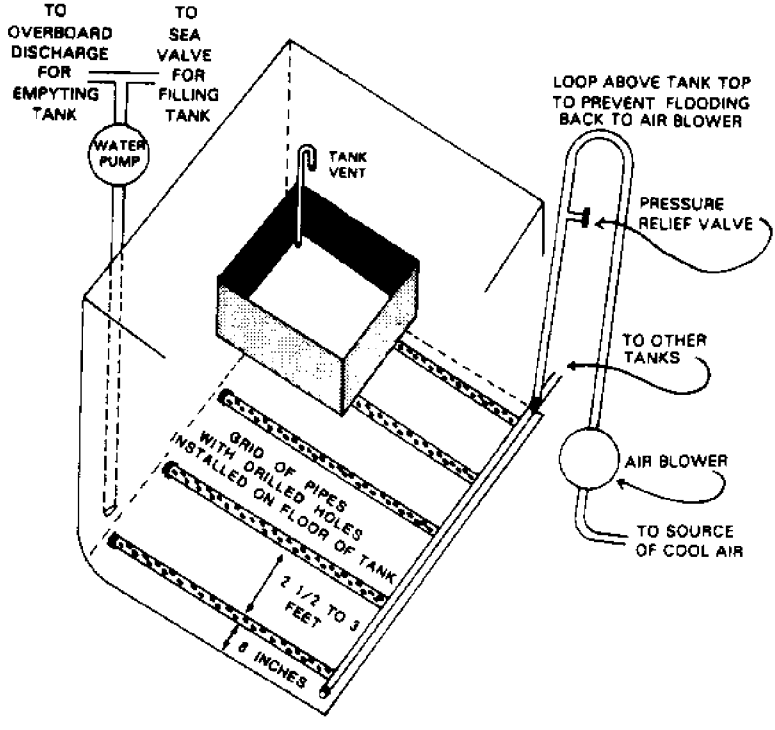

Figure 3. Schematic of chilled seawater system.

offers many advantages for small boats. It is easy to operate and maintain. It minimizes handling of the catch and quickly chills large amounts of fish. Chilling usually can be accomplished in 1 to 3 hours. No refriggeration equipment is needed since the system depends on ice for chilling. The system provides a natural buoyancy that prevents crushing and bruising.

On the negative side, without adequate ice a CSW system will not work. Temperature stratification is a major drawback. As ice melts, the fresh water layers at the top and forms a temperature gradient that prevents uniform cooling. This can be eliminated with frequent mixing. If circulation is poor, hot spots can occur in which fish do not chill, but actually warm up during storage. CSW can be easily overloaded, slowing proper circulation and chilling.

In choosing CSW as a chilling system, several factors should be considered: equipment, costs, convenience, and ice. Slush ice requires minimal equipment: a watertight tank, tote, or other container with a means of filling and emptying. The champagne system needs additional piping, pumps and space for equipment.

Will the system pay for itself in increased prices for the fish and better quality product? A small system can be installed for less than $3,000 and pay for itself over two or three seasons. Convenience is another plus, with reduced handling and easy operation. Using CSW also may eliminate frequent deliveries and extend fishing time.
Availability and cost of ice are other important factors. In areas where ice is limited or unavailable during peak periods,

CSW may not be a good choice. Determining Ice needs is complicated, and is described in Marine Advisory Bulletin No. 19, "Chilled Seawater Systems: Installation and Operation on Alaskan Vessels."

REFRIGERATED SEAWATER

Refrigerated seawater (RSW) is the most complex chilling system available (Figure 4). It has some application for fisheries where other chilling systems are not feasible. For example, systems are appearing on Bristol Bay gillnetters where ice is not readily available.

RSW provides several advantages. It permits stowing large catches of fish quickly and easily. Chilling is rapid, producing a uniform quality product. There is reduced handling, a factor that helps protect product quality. RSW eliminates the need for ice and its associated costs. It also is possible to operate the system at temperatures below freezing, providing additional cooling in other systems. And like CSW, the system has a natural buoyancy that prevents crushing and bruising the catch.

The disadvantages are equally important. Proper circulation is a requirement. Without it, chilling is slow and proper temperatures cannot be maintained. RSW has little room for error and requires proper engineering, installation and skilled operation. the mechanical system requires considerable maintenance to keep it functioning properly. RSW systems are easily contaminated, so a thorough cleaning and sanitizing schedule is very important. Since the system can be operated at below freezing temperatures,

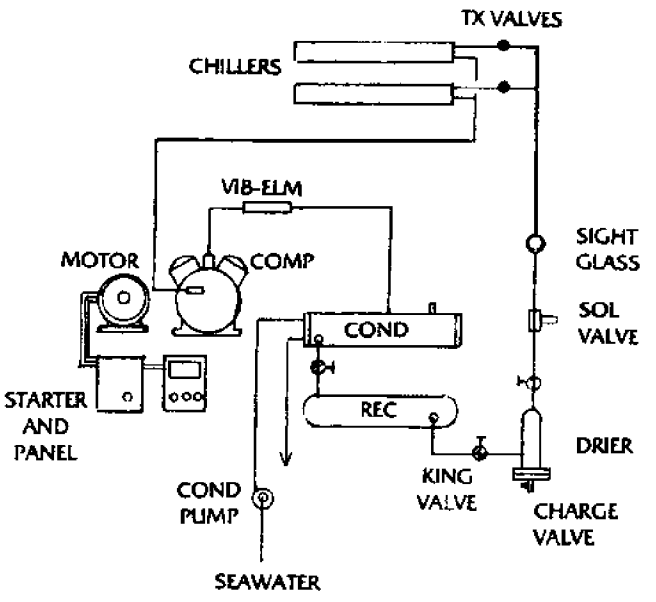

Figure 4. Schematic of RSW system. (Courtesy Thermal-Tech)

there is the problem of partial freezing and damage to roe. RSW storage also can cause color loss and salt uptake in the fish, both of which contribute to quality loss.

Installing an RSW system in a small boat requires careful consideration of installation costs, space requirements, operation, and maintenance needs.

The cost of a properly designed and engineered RSW system is a major factor in determining its applicability to small fishing vessels. In Bristol Bay, where other chilling alternatives (ice and CSW) are not feasible, RSW becomes a sensible choice. Some RSW systems can cost up to $12,000 and may take several years to pay for themselves.

Adequate space is needed for the refrigeration package as well as for access to the equipment for repair and maintenance.

One of the small packages is 4 ft long, 2 ft wide and 2 ft high. Since space on a small vessel is limited, choice of a refrigeration package becomes critical. In most cases, it probably is best to purchase a package system rather than assemble the individual refrigeration components and adapt them to the vessel.

Operation and maintenance needs must be considered. RSW systems are not easy to operate and require a high level of skill for proper operation. Knowledge of the individual system and trouble shooting ability are necessities.

Maintenance also is another area of concern because the system, must be kept in good working order for chilling to be rapid and

complete. Any failure of the system can lead to a disastrous loss of fish as well as down time waiting for repair.

CHILLING COILS

Another type of refrigeration method is chilling coils. These have been used for many years aboard older longline and halibut vessels. Coils, installed in the top of the hold, were used to chill the air and slow ice loss. In small boats, coils may have similar use.

Coils provide extra chilling capacity that may be desirable for long trips. They are additional protection against heat leaks in the system and save ice for chilling fish. Disadvantages include space needs for both the coils in the hold and the refrigeration equipment. Coils are also exposed in the hold and can be damaged.

Considerations for using coils should be cost versus benefit. Installation costs can be expensive compared with benefits.

A potential use of chilling is in immersion systems for refrigerating seawater. A similar system for temporary storage has been used on day vessels in California. It is constructed of air conditioner compressors and homemade coils providing an alternative to burlap.

Coils are not recommended as a sole source of cooling for several reasons. With coils, it is impossible to maintain any temperature control, fish become dry and dehydrated, and actual chilling is very slow.

BURLAP

A final chilling alternative is wet burlap. It provides evaporative cooling. Water evaporating from the material lowers the surface temperature and cools the fish underneath. Under the best conditions, this method can reduce the temperature of the fish only a few degrees.

The advantage of burlap is that is provides not only a small amount of cooling to slow product deterioration, but it also provides dehydration/sunburn protection for the fish.

There are several disadvantages to burlap. It provides slow surface cooling of the fish but the interior of the fish remains warm enough to keep enzymes and bacteria active. Burlap quickly becomes contaminated with spoilage bacteria so it must be cleaned frequently to lower bacterial levels and provide continued cooling. Contamination is another drawback since burlap easily absorbs gas, oil, or detergents that can adulterate fish.

Burlap should be used only as a temporary chilling method, it cannot be considered an effective replacement for any other system. It is only partially effective in slowing quality loss since the storage temperatures are well above 32^{o} F, usually in the range of 45^{o} to 55^{o} F. Burlap is suited for fisheries where chilling alternatives are not available, fishing periods are short and deliveries are made frequently. The burlap protects fish from dehydration, but does not provide adequate chilling. The sanitary condition of the burlap is another important consideration. A dirty piece of burlap can contaminate and ruin quality. Burlap is a

stop-gap measure and should not be considered an effective chilling method.

An acceptable use of burlap is in conjunction with iced storage. It can be used to cover iced fish in skiffs or at set net sites. The ice provides the chilling and the burlap helps prevent quick melting of ice.

CONCLUSION

The various chilling systems available to small vessels each have advantages and disadvantages depending on the fishery and the vessel. It is impossible to point to one system as being the best. The above discussion is not intended to be inclusive, but rather to raise questions that should be considered when choosing a chilling system. Many more questions will arise with each individual application. It is important to obtain professional assistance from manufacturers and installers as well as opinions from other users before decisions are made.

REFERENCES

ICE

FAO. 1975. Ice in fisheries. Rome, Italy: FAO. Fisheries Reports No. 59, Revision 1.

Graham, J. undated. Icemaking plant. HMSO Press: Edinburgh. Torry Advisory Note No. 68.

Merritt, J. H. 1969. Refrigeration on fishing vessels, Chapters 2 and 3. London: Fishing News Books Ltd.

Taylor, F. 1982. Ice and the quality of fish. The Fish Boat March 1982.

Tretsven, W. and H. Barnett. 1970. Recommendations for handling and icing Pacific halibut aboard vessels. Fishery Industrial Research 6(1):5-13.

Waterman, J.J. undated. Which kind of ice is best? Edinburgh: HMSO Press. Torry Advisory Note No. 21.

CSW

Alaska Seafood Marketing Institute. 1984. Quality Notebook: Chilling: Choosing a system that works for you. Juneau, Alaska: ASMI.

Alaska Seafood Marketing Institute. 1984. Quality Notebook: Chilling systems, RSW vs. champagne. Juneau, Alaska: ASMI.

Bartlett, C. 1979. Champagne ice: The foamy facts. The Fishermen's News December.

Crapo, C. 1985. Chilled seawater systems: Installation and operation aboard Alaskan vessels. Fairbanks, Alaska: Alaska Sea Grant College Program. Marine Advisory Bulletin No. 19.

Dagbjarrtsson, B., Valdimarsson, G., Arason, S. 1982. Icelandic experience in storing fish in chilled seawater. In Proceedings of the International Institute of Refrigeration conference: Advances in the refrigerated treatment of fish, pp. 233-42. Boston: IIR.

DFO. 1980. Operation of champagne systems. Ottawa: Department of Fisheries and Oceans Technology Services Branch. Unpublished Technical Information Bulletin No. 80-1, August 5.

FAO. 1975. Ice in fisheries. Rome, Italy: FAO. Fisheries Reports No. 59, Revision 1.

Gibbard, G. S. Roach, F. Lee. 1979. Chilled seawater system data sheet. Vancouver, B.C.: Department of Fisheries and Oceans. Circular No. 47, Technological Research Laboratory.

Hansen, P. 1982. Containers for chilling stowage and transport of fresh fish in ice water. In Proceedings of the International Institute of Refrigeration conference: Advances in the refrigerated treatment of fish, pp. 251-58. Boston: IIR.

Kelman, J.H. undated. Storage of fish in chilled seawater. Edinburgh: HMSO Press. Torry Advisory Note No. 73.

Kolbe, E., C. Crapo, K. Hilderbrand. 1986. Ice requirements for chilled seawater systems. Submitted to Marine Fisheries Review.

Kramer, D. E. 1981. Chilled and refrigerated seawater. Alaska Seas and Coasts 8:4:1.

Lemon, D.W., L.W. Regier. 1976. Slush ice holding of mackerel. Halifax, N.S.: Fisheries and Marine Service, Environment Canada. New Series Circular No. 56, Technological Laboratory.

Merritt, J. H. 1978. Refrigeration on fishing vessels, Chapter 6. London: Fishing News Books Ltd.

Pennington, H. 1984. Champagne ice can provide that extra margin of profit. National Fisherman 65:1:60.

RSW

Alaska Seafood Marketing Institute. 1984. Quality Notebook: Fully flooded or spray brine. Juneau, Alaska: ASMI.

Bronstein, M, R. Price, E. Strange, E. Melvin, C. Dewees, and B. Wyatt. 1985. Storage of dressed chinook salmon in refrigerated freshwater, diluted seawater, and ice. Marine Fisheries Review 47(1):68-72.

FAO. 1975. Ice in fisheries. Rome, Italy: FAO. Fisheries Reports No. 59, Revision 1.

Gibbard, G. and S. Roach. 1976. Standards for an RSW system. Vancouver, B.C.: Environment Canada Fisheries and Marine Service. Technical Report No. 676.

Graham, J. and S. Sykes. 1982. Refrigerated seawater--its use in Australia. Australian Fisheries December.

Harrison J. and S. Roach. 1955. Transport and storage of fish in refrigerated seawater, I: Refrigerated sea-water installation on the vessel J.R.D. Fisheries Research Board of Canada Progress Report of the Pacific Fisheries Experimental Station 104:3-6.

Kelman, J. H. undated. Stowage of fish in chilled seawater. Edinburgh: HMSO Press. Torry Advisory Note No. 73.

Kolbe, E. 1977. Marine refrigeration: Some tips on design, installation and servicing. Corvallis, Oreg.: Oregon Sea Grant College Program. Extension Sea Grant Special Report No. 448.

Kramer, D.E. 1981. Chilled and refrigerated seawater. Alaska Seas and Coasts 8:4:1.

Merritt, J. H. 1978. Refrigeration on fishing vessels, Chapter 6. London: Fishing News Books Ltd.

Roach, S. 1972. Operating instructions for RSW systems on B.C. salmon packers. Vancouver: Fisheries Research Board of Canada Laboratory.

Roach, S., H. Tarr, N. Tomlinson and J. Harrison. 1967. Chilling and freezing salmon and tuna in refrigerated seawater. Ottawa: Fisheries Research Board of Canada. Bulletin No. 160.

CHILLING COILS

Merritt, J. 1978. Refrigeration on fishing vessels, Chapter 5. London: Fishing News Books Ltd.

BURLAP

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