6. Containers and fish holds

6.1 DESIGN OF INSULATED BOXES AND CONTAINERS FOR CANOES AND SMALL FISHING VESSELS

Many types of containers, constructed from a variety of materials, are used for the transport of ice and fish – from simple baskets of woven reeds, bamboo, cane or grasses, to containers made from wood, metals and plastics. In order to reduce the melting of ice, insulation materials such as those discussed in Chapter 5 may be used in the construction of containers. Use of any particular type depends very much on the economic situation of the locale and fishery being pursued.

Although estimates vary, in some situations a high proportion of fresh fish caught in tropical and subtropical areas may be wasted, with the major loss in quality and value occurring between harvesting operations and first sale in landing areas. It is envisaged that with the increased availability and wider use of properly designed containers for use on canoes and small fishing vessels, there will be scope for reducing wastage of fresh fish in small-scale fisheries.

However, there are a number of factors that limit the achievement of this goal. These include the relatively high cost of insulated containers and the fact that ready-made containers are generally manufactured in industrialized countries and need to be imported. The extra costs involved in the purchase of metal or plastic boxes are sometimes sufficient to deter fishermen from using them. They opt instead for the traditional locally made containers or baskets with their lower investment cost. As a fishery becomes more developed and product quality becomes an issue, the trend to purchase plastic or metal boxes increases.

In some tropical areas, the cost and availability of ice are limiting factors, rather than the cost of insulated containers. Besides the existing technological limitations in some tropical areas, there is scope for developments in the design and construction of locally made insulated containers, which should eventually make them more easily available and inexpensive enough for small-scale fishermen.

6.2 INSULATED FISH CONTAINERS

The main functions of an insulated fish container on board canoes and small fishing vessels are:

- to make handling easier (by reducing the handling frequency of individual fish) and protect the fish from the risk of physical damage;
- to maintain fish quality, by ensuring adequate chilling and low ice-meltage rates as a result of reduced heat infiltration through container walls;
- to improve fish-handling practices and so lead to better quality fish being landed, making longer fishing trips and better fish prices possible for fishermen.

The effectiveness of insulated containers in reducing ice melting is an important criterion in the evaluation and selection of such containers. It is more likely that the advantages that insulated containers offer will be fully appreciated by small-scale fishermen in tropical climates where ice meltage rates are much higher than in cold or temperate climates.

6.2.1 Design factors and construction aspects

The main general design features for insulated containers (both portable and fixed types) are as follows:

- They should be suitable for transportation on fishing vessels and road vehicles (which can be of different types and sizes). Therefore, portable containers should have special features, making them well suited for handling catches on board, as well as for storage and transport of fish on shore.
- They should be able to withstand relatively rough handling.
- They should have drains for ice melt water.
- They should be constructed of materials that allow easy and thorough cleaning.
- They should be of a suitable size for accommodating the range of fresh fish caught, so that they are not bent or distorted in any way.
- They should be of a suitable size for adequate manual handling or fork lifting, if these machines are available.
- Portable types should be suitable for secured stacking, so that the weight of the containers on top falls on the containers underneath and not on the fish inside the container.
- They should be constructed of lightweight materials.
- They should be strong.
- They should possess good insulating properties to avoid high heat infiltration, rapid rises in temperature of fish and quick ice meltage.
- The optimum design of an insulated container should consider an adequate storage depth to avoid crushing the fish at the bottom, i.e. it should avoid deep bulk storage. The containers should be of simple construction and the insulation should not occupy too much space.

Table 6.1 gives some information on the physical characteristics of materials that may be used for the construction of fish containers.

6.2.2 Commercially manufactured insulated containers

There is a wide range of insulated containers available, offering a variety of features according to different requirements of handling, size, insulation efficiency, modes of transportation, sturdiness, durability and construction materials. However, these insulated containers are generally an imported item in developing countries, which means that they are costly, especially when compared with non-insulated boxes and locally made traditional fish containers.

Insulated container capacity or physical size has undoubtedly also been a limiting factor in introducing these units to some markets in developing countries' fisheries. Many such fisheries lack the infrastructure and equipment, such as cranes and fork-lift trucks, for the physical handling of large tubs when full of ice and fish. Most fish-landing sites at artisanal level still rely on manual handling, which effectively places a limit on the size of items that can be used.

TABLE 6.1
Characteristics of some materials used in the manufacture of fish containers[1]

Type of material	Density	Thermal conductivity	Material strength	
			Tensile strength	Bending strength
	(kg/m³)	*(W m⁻¹ h⁻¹ °C⁻¹)*	*(kg/mm²)*	
Wood (soft)	350–740	0.11–0.16	5–8	8–12
Wood (hard)	370–1,100	0.11–0.255	8–14	10–15
Plywood [2]	530	0.14	3.5–9.3	variable
Aluminium alloy	2 740	221	20–30	30–40
Mild steel	7 800	45.3	24–43	20–28
Fibreglass-reinforced plastic	64–144	0.036	20–50	30–100
High-density polyethylene	960	0.5	5–10	13–15
Eel grass between strong paper (not compressed)	73.6	0.036	–	–
Eel grass in burlap (not compressed)	215	0.049	–	–
Jute fibre (not compressed)	107	0.036	–	–
Polyethylene sheet plus 2 layers of gunny (jute) fabric plus polyethylene sheet (not compressed)	500	0.054	–	–
Polyethylene sheet plus 4 layers of gunny (jute) fabric plus polyethylene sheet (not compressed)	580	0.046	–	–
Cane fibre insulation board (not compressed)	*216*	*0.048*		

[1] Figures given must be taken only as indicative values due to the great variation within materials.
[2] Tensile strength of three-ply wood parallel to grain of faces; under flexure plywood boards have about 85 percent of the bending strength of a solid beam of the same wood and same size.

Common materials used for the manufacture of insulated containers are FRP and high-density polyethylene (HDPE) often with plastic foams for insulation.

One of the most common types of insulated container used in fisheries consists of double-walled HDPE with expanded polystyrene or polyurethane foam as insulation. These are usually constructed in a single piece using a rotational moulding process. The HDPE walls vary in thickness from 3 mm to 6 mm and the total thickness varies according to the size and capacity of the insulated container. These types of containers are able to withstand relatively rough handling, and are considered to be superior to those manufactured with other materials, such as FRP, which tends to be more brittle and prone to impact damage and fractures.

However, HDPE is an expensive material, derived from a petrochemical, whose market prices are linked to oil prices. With correct handling, HDPE insulated containers can have an expected lifespan of about five to seven years. Generally, HDPE containers are not repairable and usually have to be replaced if broken. However, medium-density polyethylene containers can be repaired by welding.

HDPE is rated as capable of withstanding temperatures up to 100 °C and down to -40 °C. However, it becomes brittle at low temperatures, and for this reason HDPE containers are not well suited to use at low temperatures, in frozen fish stores, for instance. Commercially available containers vary from 50 litres capacity up to 1 100 litres. Recommendations for handling HDPE containers are given in Box 6.1. The thermal efficiency of HDPE containers varies according to

BOX 6.1

Recommendations for handling HDPE containers

- The containers should not be punctured with knives, gaffs or needles, as this can damage the HDPE layer that protects the polyurethane foam insulation, resulting in poor thermal performance and significantly reducing the useful life of containers.
- HDPE containers should not be exposed to temperatures above 50 °C or to temperatures below –40 °C; in addition they should not be exposed to direct fire.
- Despite the fact that HDPE containers are manufactured with impact-resistant materials, they should not be exposed to heavy mechanical stress (such as excessive load weights and very rough and abusive handling).
- HDPE containers, after use, should be adequately cleaned with water, brushes, sponges and detergents or foam wash, either manually or with high-pressure washing equipment. Care should be taken to store them well dried because, when they are closed, there is very little water evaporation, so if some water remains inside it could facilitate the growth of moulds and bacteria. It is important to avoid the used of organic solvents for cleaning HDPE containers.

TABLE 6.2

Technical features and thermal conductance of some HDPE containers

Net capacity (litres)	Polyurethane insulation thickness (mm)	Thermal conductance (W m^{-2} °C^{-1}; kcal m^{-2} °C^{-1})	Approximate weight (kg)
70	30–50	0.546 (0.4695)	12
200	30–50	0.388 (0.3336)	25
450	30–50	0.388 (0.3336)	63
680	57–63.5	0.310 (0.2668)	66

Source: HDPE insulated container manufacturers from Canada and Denmark.

the intended use and design. Table 6.2 shows examples of thermal conductance of some HDPE containers used for chilled fish handling.

6.2.3 Locally made insulated containers

A wide range of materials are used in the manufacture of insulated containers in developing countries, including wood, plywood, bamboo, metal sheets (galvanized iron and aluminium alloys), nipa, palm leaves, wood shavings and sawdust, dried straw and grass, coconut husks and rice husks. More recently, plastics such as polyurethane foam, expanded polystyrene, polyethylene sheets, PVC and FRPs have been used. Small-scale fishermen in developing countries have gradually become aware of the advantages of insulated containers and efforts have been made to design suitable containers making use of locally available materials. In most tropical areas, the main innovative approach has been to incorporate insulation materials into the existing designs of locally made fish containers, therefore offering improved versions, but maintaining the traditional container's features of being a practical and low-cost alternative well suited to local conditions.

Another approach has been to design new types of insulated containers that can be fitted in the existing canoes, pirogues or small fishing vessels, according to the type of fishing operation, and the quantities and characteristics of the most abundant species caught. However, the most critical features in the manufacture of locally made insulated containers are the proper selection and availability of insulation materials, adequately trained personnel for construction and repairs and provision of on-the-job training to fishermen in adequate handling practices for containers to minimize damage and subsequent poor performance. In several tropical areas, there have been successful attempts to introduce locally made insulated containers on board small-scale fishing vessels. Table 6.3 describes several examples of these locally made insulated containers (see also Figures 6.1 and 6.2, pp. 74 and 75)).

The successful introduction of improved containers or new types of insulated containers in small-scale fisheries depends on several factors. Therefore, field trials are required to establish reliable performance and economic data under prevailing working conditions. In practice, the viability of a locally made container will depend on the priorities of the fishermen and the market requirements (export quality or for domestic markets), for example. If the containers are too heavy, or of low capacity due to the insulation occupying too much space, or not strong enough under existing working conditions on board, fishermen may not be able to use them regularly. Ease of cleaning and hygiene are also critical factors if the product is to be exported internationally.

In some tropical areas, locally made moulded expanded polystyrene containers are widely used for handling chilled fish in small-scale fishing vessels. For example, in the Philippines, moulded expanded polystyrene containers of 30–40 kg capacity (approximate inner dimensions: L = 51 cm × W = 35 cm × H = 35 cm) are used on board outrigger canoes and small fishing vessels for chilling fish as well as for transport (sea and road) and marketing. The polystyrene is protected by external wooden frames or galvanized steel sides that help to support and protect the container, and withstand rough handling. Figure 6.3 (p. 76) shows one typical arrangement. The main advantages of these containers are that they:

- are easy to handle;
- have good insulating properties;
- are relatively cheap;
- are readily available.

Their main disadvantages are that they:

- are difficult or impossible to clean properly;
- have a weak physical structure;
- do not nest when empty;
- have a relatively short useful life.

These containers are widely used for road transport of high-value chilled fish and shrimp and it is estimated that their useful life is about 8–10 long-distance

TABLE 6.3
Examples of locally made insulated containers for small fishing vessels

Geographic area	Characteristics of container	Type of fishing vessel	References
Asia (India)	Capacity: 175–200 kg of ice/fish mixture Weight: 40 kg Design: FRP and polyurethane foam (70 mm thick). With 10 mm diameter drainage Technical and financial viability studies were conducted, based on field trials with eight vessels	Traditional 5–12 m long wooden fishing vessel known as "navas"	FAO (1991)
Africa (Senegal)	Capacity: 0.9–1.3 tonnes of fish Weight: 200 kg (with two hatches) and 270 kg (with 3 hatches) Design: FRP and polyurethane foam (100 mm thickness). With PVC pipe drainage. Tailor-made to fit local pirogues Technical and financial viability studies were conducted, based on field trials with several vessels (Evaluation Report, Phase I, Project: "Amélioration de la conservation de poisson à bord des pirogues", CAPAS, Senegal, 1983 and FAO project GCP/INT/398/NOR) Later on, based on this design, several experiences on the introduction of insulated containers for small-scale fishing vessels were undertaken in the United Republic of Tanzania, Kenya, the Gambia, Guinea-Bissau and Guinea.	Traditional 14–18 m long wooden pirogues with outboard engines	FAO (1985)
Asia (Indonesia)	Nominal volume: 5.15 m^3. Approximate external dimensions: L = 4.96 m × W = 1.33 m × H = 0.78 m Design: CSW insulated container constructed of wood board, expanded polystyrene foam, FRP lining on the inner surface. Tailor-made to fit local purse seiner. Technical viability studies were conducted by the Research Institute for Fish Technology in Jakarta, based on field trials with one prototype vessel. In 1986, three years after the introduction of the CSW container in the Bali Strait area, about 78 purse seiners were equipped with CSW containers.	Traditional 12.2 m long purse seiner (main species caught: *Sardinella longiceps*).	Putro (1986)
Asia (Indonesia)	Capacity: 48 kg ice/fish mixture Weight: 24 kg External dimensions: L= 1 025 mm × W = 295 mm (top) and 260 mm (bottom) × H = 400 mm Design: FRP laminated onto an insulated container consisting of expanded polystyrene foam (25.4 mm thickness) lined with 6.5 mm plywood with an aluminium angle bar framework. Access to the insulated container is through two lids of 505 mm × 280 mm, located at both ends of the top surface. A rubber gasket 20 mm × 10 mm is fitted around both insulated lids. Heavy duty ropes were fitted on both ends as handles to assist in lifting the container. A single 10 mm diameter PVC pipe and plug was fitted through the insulated container at one side of the end of the container. Tailor-made to fit local canoes. Two versions were constructed. The second version was without FRP lining; it was made of a wooden framework with plywood as the outer shell, with 25.4 mm expanded polystyrene foam as insulation and an aluminium sheet lining. Both versions had similar external dimensions. The second prototype weighed 17 kg. The cost of the wooden version was about 50 percent of the FRP container's cost. These containers were designed specifically for chill storage of red snappers, which were the most important species in the deep water operations and export marketing of the project. Initial field trials were carried out on two canoes; later, the project "Cenderawasih Bay Coastal Area Development" (UNDP/FAO INS/88/0911) continued with the field tests	Non-motorized traditional fishing dugout canoes (4–6 m Loa). In practice these canoes were catching on average 10–20 kg/day of high-value red snappers with deep water handlines. Only occasionally could they catch large quantities of, say, 40 kg/day. These canoes were generally working within a motherboat system, transferring the catch at the end of the day to the motherboat's fish hold	FAO (1992a)

TABLE 6.3
Cont.

Geographic area	Characteristics of container	Type of fishing vessel	References
South America (Ecuador)	Capacity: several types of containers were made with nominal volumes from 1.166 m3 to 1.224 m^3 Weight: complete with tops, from 72 to 89 kg Design: Three types of insulated containers were made, namely: a) wooden sides (consisting of a wooden framework and plywood) and wood as lining with 25 mm thick expanded polystyrene insulation; b) same as container (a) but with galvanized iron sheet as lining; c) same as container (a) but with polyurethane foam and FRP lining. The FRP laminated container was considered the most promising in terms of lightness and durability Four FRP-laminated insulated containers were constructed and long-term durability tests were carried out by the project ODNRI/ODA (Overseas Development Natural Resources Institute/ Overseas Development Agency) with the Instituto Nacional de Pesca. In recent years, another tailor-made FRP-laminated container (with 50 mm polyurethane foam as insulation) was field-tested and introduced in several small-scale fishing communities by the project "Technical Cooperation Programme for Fishing" UE-VECEP ALA 92/43, with promising results. Similar FRP-laminated containers were also field-tested by the UE-VECEP ALA 92/43 project in Colombia	Traditional small-scale fishing vessels and canoes, but these containers (type (a), (b) and (c)) were specifically designed for FRP launches (7.2–7.5 m Loa) engaged in fishing for dolphinfish (*Coryphaena* sp.)	Wood and Grijalva (1988) Acero, (1997)[1]; Tilman (1999)[2]

[1] Acero, 1997. Personal communication regarding field-testing of insulated containers in small-scale fishing vessels in Colombia and references to a pilot activity in Ecuador for the introduction of insulated containers by Project EU-VECEP ALA 92/43.
[2] Tilman, 1999. Personal communication and references regarding the introduction of insulated containers in small-scale fishing vessels in Ecuador by Project EU-VECEP ALA 92/43.

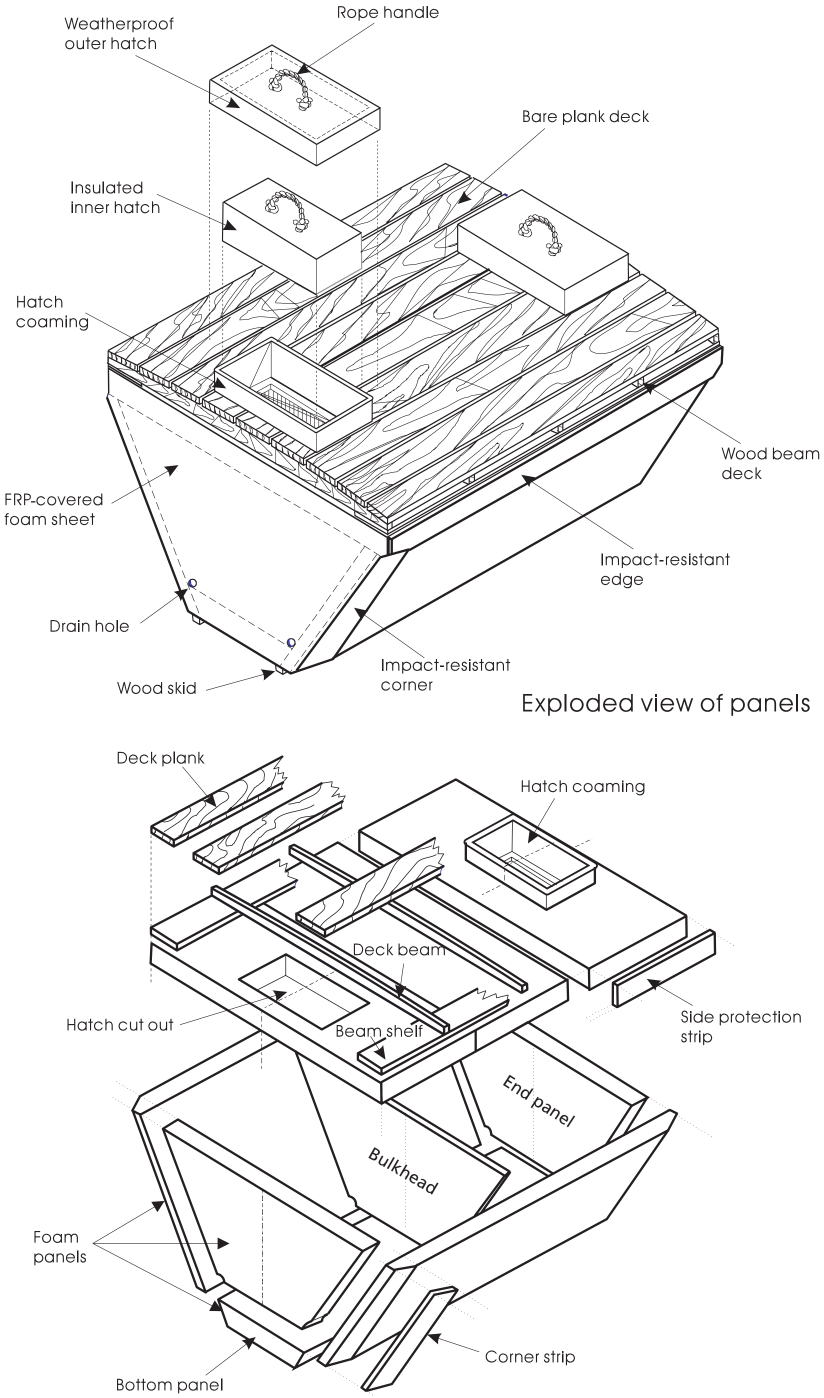
trips (or two months) with external wooden frame and 20–24 long-distance trips (or five to six months) with galvanized steel sides.

6.2.4 Locally made non-insulated fish boxes

Where the costs of plastic fish boxes are too high, wooden boxes are often used because the boxes are simple to construct using basic hand tools, can be repaired if damaged and are less costly than plastic imports. A typical locally made wooden box for fresh fish on ice stowage is shown in Figure 6.4 (p. 76). Generally, wood of suitable type and dimensions can be easily found locally. Another advantage of locally made boxes is that they may be made to any special dimensions required for local species. This is important as box sizes must be large enough so that fish are not bent or distorted when stowed in the box with ice.

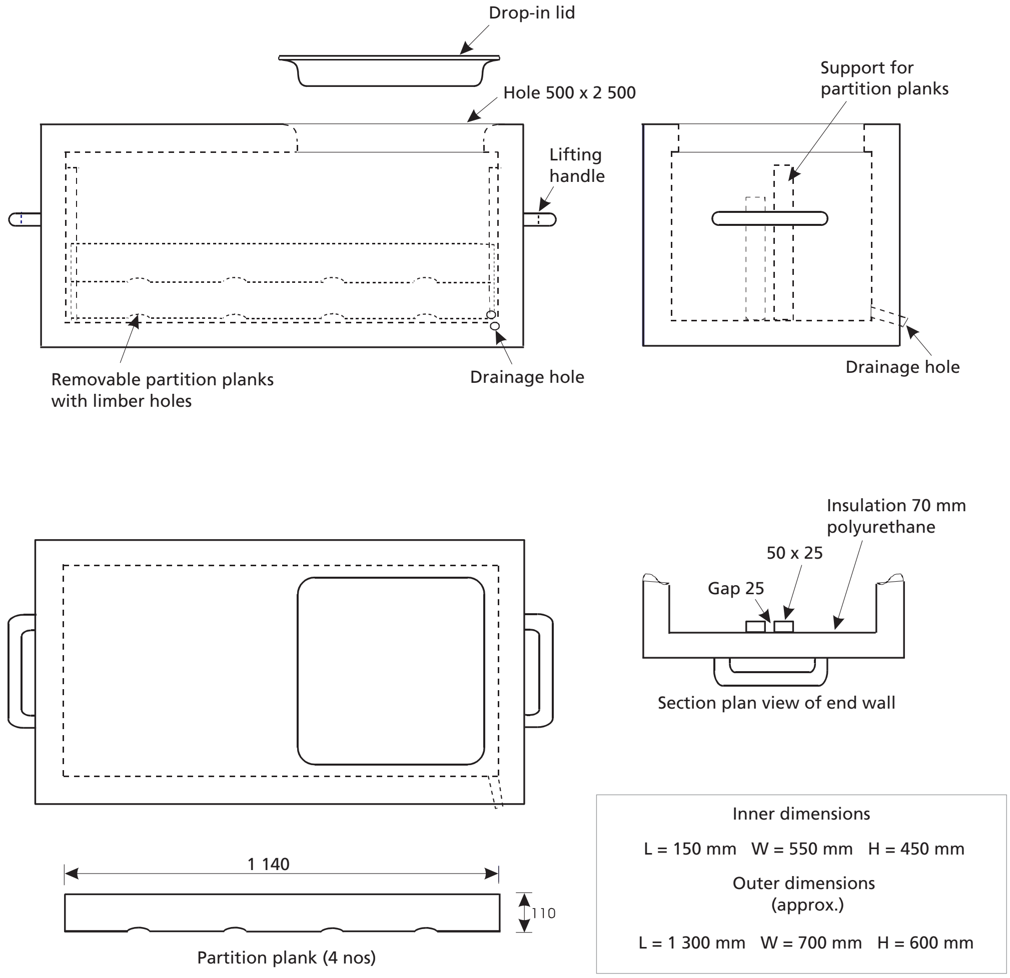
However, there are some disadvantages to wooden boxes: they can be heavy and they absorb moisture, which may include fish slime, blood and other fish wastes and bacteria. This can then contaminate the fish stored in them causing accelerated spoilage or infection with pathogenic organisms. The problem of maintaining hygiene in wooden boxes can be addressed by immediate washing of the box after use using brushes and a disinfectant solution containing chlorine or a similar cleansing agent. Besides the regular washing and disinfecting, it is also common practice to line the box interior with clean polyethylene sheet material, effectively keeping the fish from coming into contact with the box. The polythene sheets should be discarded after use.

FIGURE 6.1
Example of a customized insulated fish box (West Africa)



Source: FAO, 1985.

FIGURE 6.2
Standard shape insulated fish box (India)



Note: all measurements are in millimetres (mm)

6.3 FISH HOLD DESIGN

When building a new fishing vessel, the fish hold can be designed and installed for maximum efficiency from the beginning, which overcomes the difficulties that can be encountered when retrofitting fish holds and insulating them in existing vessels.

6.3.1 Penboards, shelving or boxes: benefits and disadvantages

When considering hold design for small-decked artisanal fishing vessels, the various methods of catch stowage generally encountered are:

- piled on hold floor;
- piled in ice on hold floor;

FIGURE 6.3
Common styrofoam box with lid and protective wooden frame

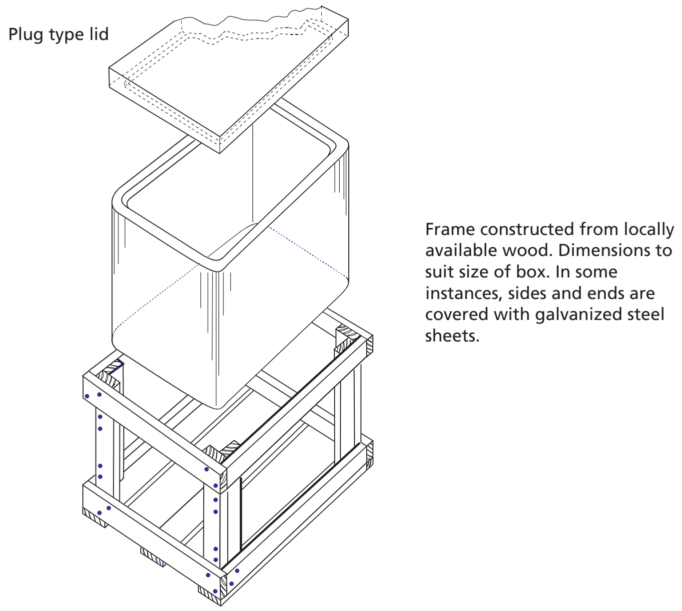
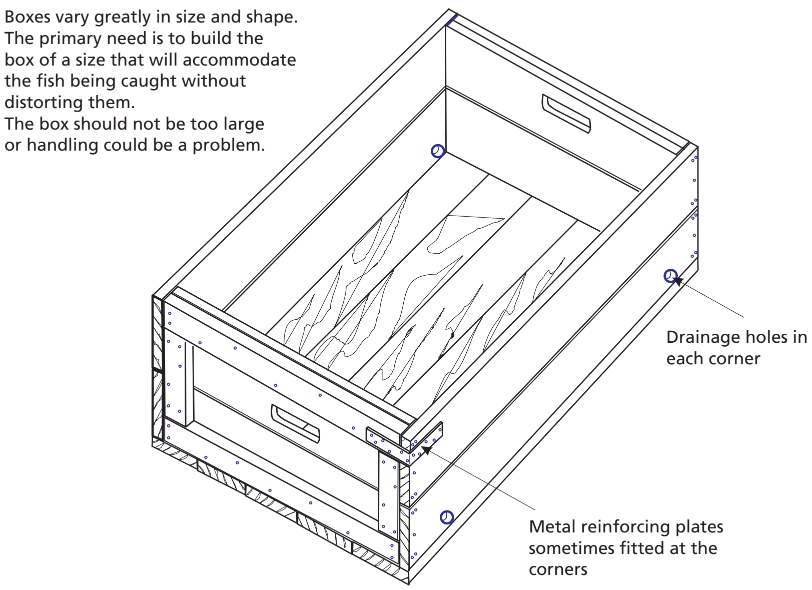


FIGURE 6.4
Typical locally made wooden fish box, uninsulated



- stacked with ice in divided compartments;
- shelved with ice in divided compartments;
- stored in fish boxes with ice;
- stored in insulated tubs or hold tanks with ice or CSW.

Obviously, the first two methods are to be avoided if at all possible because they will produce poor quality, damaged and consequently low-value fish. Damage to the catch is also incurred by the crew walking over the pile. Further damage to fish at the bottom of pile is also caused by compression of the lower layers from the weight of the stack – the higher the stack, the more compression damage is incurred. Other damage is incurred by the lower layers of fish being bathed in waste fluids and contaminated with decay bacteria. If the pile includes ice meltwater from the fish stacked above, this will tend to have a cleansing effect, provided that sufficient quantities are used.

An advantage of stacking fish in divided compartments is that it allows the catch to be sorted according to species and size, etc. However, the problems of compression damage, weight loss and contamination are still factors to be considered.

An improvement on the above type of bulk stowage compartment is to provide shelving at pre-set heights within the compartment, which alleviates the problem of crushing fish at the bottom of the stack. Practical research work carried out on commercial fishing vessels in New England by the New England Fisheries Development Foundation Inc. found that the optimum shelving height was around 53 to 61 cm (21–24"). European and Canadian studies on shelf stowage of fresh fish are in agreement with these figures.

One disadvantage with the bulk stowage of fish is the necessity for extra handling. The catch has to be physically handled from capture to stowage in the hold and again at dockside when unloading, causing more delay and damage to fish. In some countries the handling time is costly, so efforts have been made to streamline the process. In Canada, for instance, net bags have been layered in with fish and ice, allowing the deck boom to lift fish out layer by layer instead of individually transferring them to boxes for removal from the hold. This system also has its flaws, as there is still damage to a certain percentage of the catch caused by the net during unloading. Fish pumps are also used, but primarily for small pelagics. Some pumping systems can also cause damage to the larger fish, signifying further losses of quality and consequently lower prices.

One of the best alternatives for catch preservation and minimizing handling is the use of stackable tote boxes and more recently the introduction of insulated plastic containers or tubs.

Fish tote boxes can be made from wood, metals or plastics, with each material having its advantages and disadvantages, as shown in Table 6.4.

The plastic non-insulated fish box has become the standard for fresh fish stowage on board fishing vessels in many countries worldwide because of its obvious advantages over other materials. This is especially so if export of the product is taking place or being contemplated. The export market consistently demands high quality and good standards of hygiene, which can be best complied with by using HDPE tote boxes (see Figure 6.5).

TABLE 6.4
Characteristics of non-insulated fish boxes

Material	Advantages	Disadvantages
Wood	Depending on location or country, wood may be cheap to manufacture, and may be the only material readily available for this purpose at reasonable cost to the fishermen Carpentry skills for manufacture and repair of boxes are readily available in most countries Can be readily made to sizes to suit local requirements	Relatively limited lifespan of box due to rough handling procedures and constant repair. Frequent replacement required Considerable waste of sometimes valuable forest resources Difficult to keep properly clean and sanitized Heavy – to be strong enough for rough handling boxes are made of heavy stock
Metal	Metal boxes are normally of welded lightweight alloy Relatively strong and light for handling Resistant to rough handling Easily kept clean Relatively durable	Generally quite expensive compared to wood or plasticnot always available locally Repairs relatively easy if alloy welding equipment available Very noisy to handle
Plastic	Reasonable cost Lightweight, strong and durable Commercially available in most parts of the world Designed specifically for fisheries use regarding ease of manipulation and stackability in fish holds Easy to keep clean	Hard to repair if damaged Can be more costly initially than wooden boxes Some types do not nest one inside the other; this can cause stowage space problems for empty boxes

There are some differences in the plastic tote boxes available to fishermen, primarily in the storage methods for empty boxes. Some boxes are constructed in such a way that they nest one inside the other, which is a great benefit when space is at a premium, as is normally the case on many small fishing vessels. The non-nesting types tend to be used on larger fishing vessels such as wet fish trawlers, where space is not such a critical factor. All modern plastic fish boxes are designed in such a way that wastes and meltwater from the boxes in the upper layers of the stack do not drain into the boxes below.

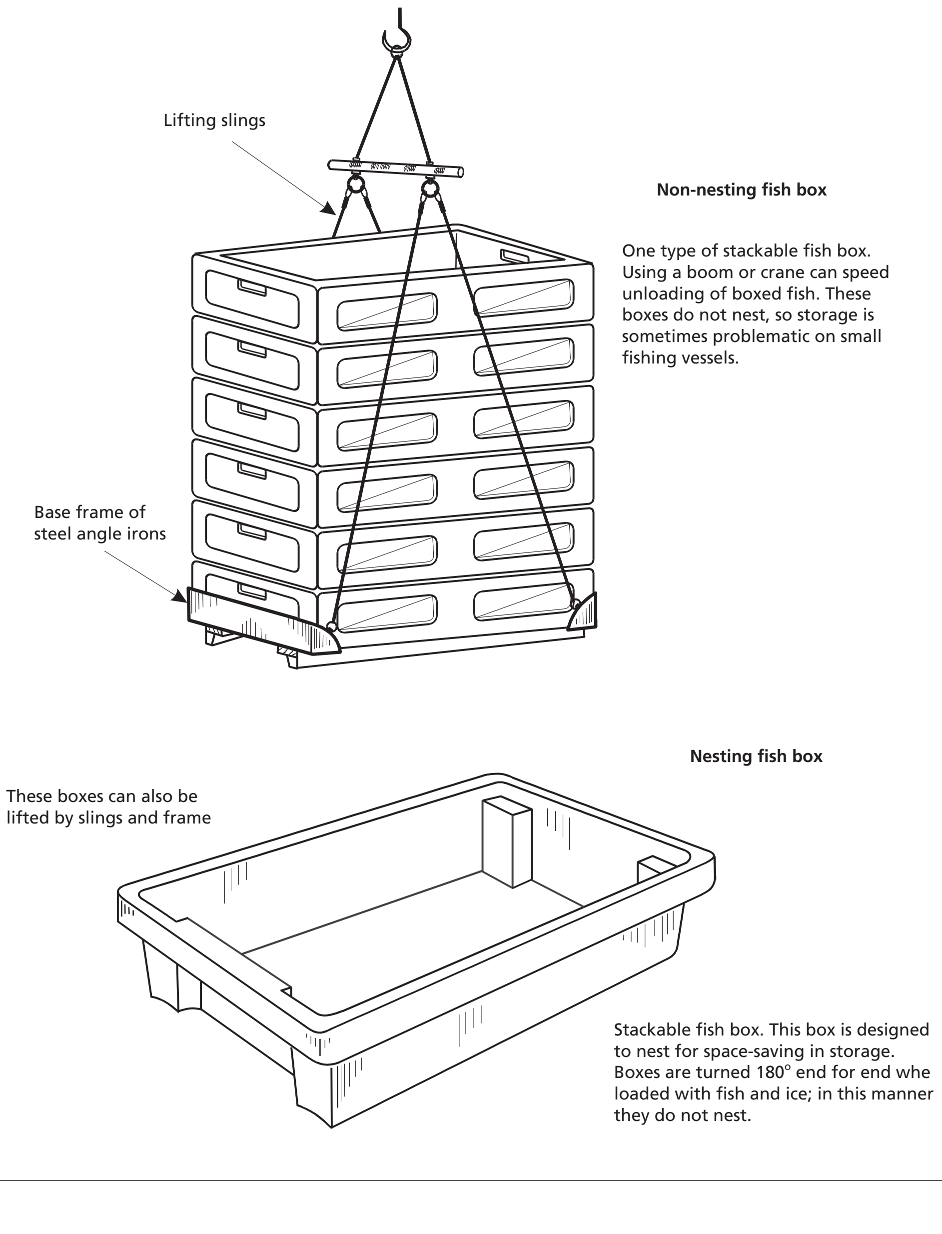
6.3.2 Insulation: design considerations

Factors in the design of insulation in fish holds are principally concerned with obtaining the best R-value figures for the insulation type chosen and the best available material for the fish hold liner, without losing excessive interior volume while being economically feasible.

Basic assumptions for insulation are that heat gains in the fish hold will be greater through engine room bulkheads and working decks exposed to direct sunlight – consequently these areas will require more insulation. For more information on insulation types and suitability for fishing vessels, refer to Chapter 7.

In modern vessels, the insulating material usually chosen for installation during construction is expanded closed-cell polyurethane foam or one of its derivatives. This foam is usually sprayed in place in the hold to slightly more than the required thickness. When set, the foam surface is trimmed to uniform thickness using rotary rasps or hand tools. A sheathing of fibreglass or other suitable material

FIGURE 6.5
Stackable HDPE boxes



is then applied over the foam to provide damage protection, an easily cleanable surface and protection against ingress of moisture. The use of polyurethane foam is advantageous in that it does not dissolve or break down from the effects of styrene in the fibreglass sheathing, as happens with expanded polystyrene-based foams.

Some proprietary surface finishes are also used to cover and protect sprayed-in-place foam. One such material is a type of cement plaster with polymer additives. This is applied using a plastering trowel to a thickness of about 12 mm over the foam.

The sheathing thickness is sufficiently heavy to provide mechanical strength also, so that should blocks of ice or fish boxes be dropped in the hold, the sheathing will not easily fracture leaving difficult-to-clean crevices where bacteria will propagate.

Polystyrene-based foams have to be protected from direct contact with styrene that is present in polyester resins used in typical fibreglass lay-ups. Some methods commonly used to line holds and protect styrofoam are:

- Thin sheet metal linings, usually zinc, galvanized steel or aluminium. Zinc and galvanized steel are not to be recommended because of the toxic qualities of zinc. Aluminium is good but expensive and can be difficult to install.
- Epoxy/glassfibre laminates as a barrier layer prior to polyester laminate lay-up application. This is a good system, but depends on costly epoxy laminating resin, which is not always available in many countries.
- Ferro-cement or modified plasters. Cement workers and skilled plasterers are available in practically all countries. The ferro-cement method, when properly applied with layers of wire mesh reinforcing, is one of the cheapest, best and most readily available. This method is well proven, having been used to construct many fishing vessel hulls of exceptional strength over the past 40 years.

Other forms of insulation, such as cork board or cork granules, are also in common use, though R-values are not as high as for the plastic foams. Materials of a highly hygroscopic nature, such as fibreglass wool, rock wool, sawdust and straw, should normally be avoided in insulating fishing vessel holds, because when they become wet they lose practically all their insulating value. Also, some of the vegetable-based materials tend to attract insects or vermin of various types.

Ultimately, the selection of a hold-lining system is up to the builder or owner of a new vessel or one being retrofitted. They will make the final decisions based on what materials and skills are available locally and what they feel will give the results required within the budget available.

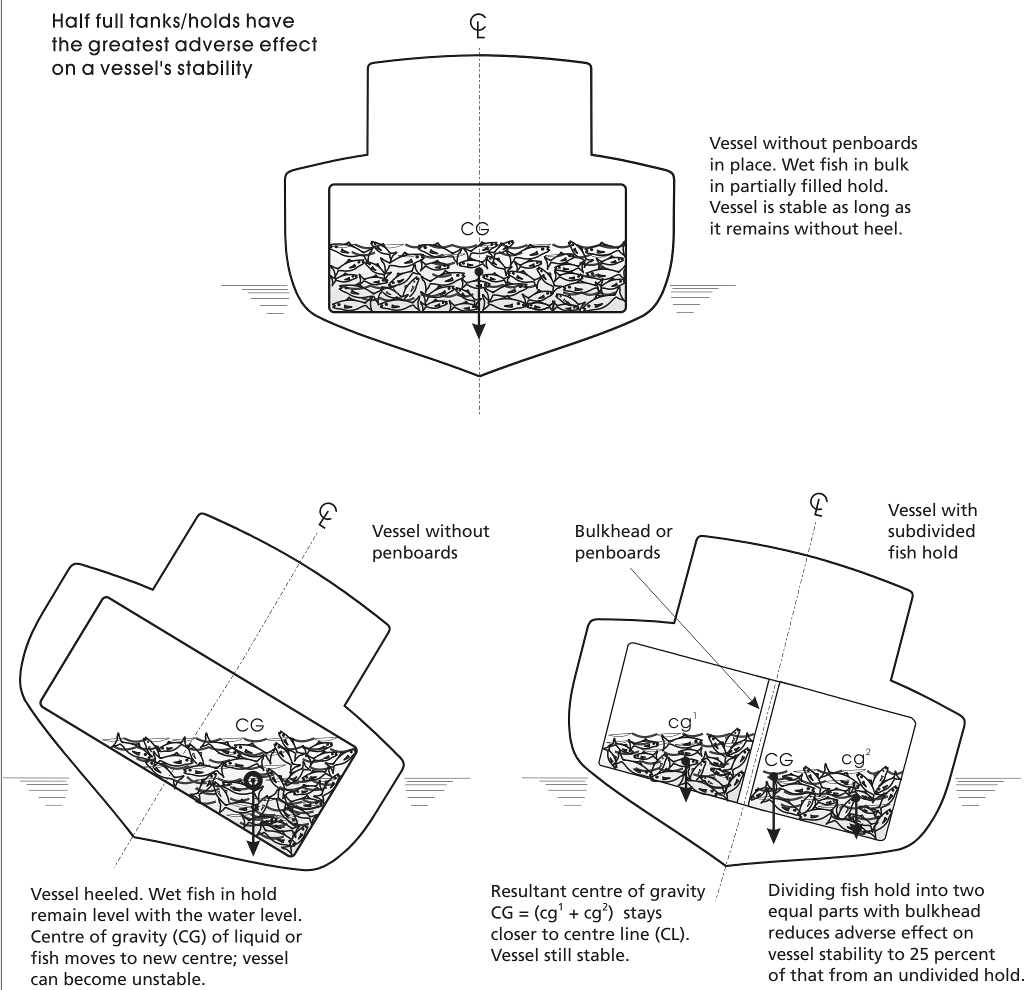
6.3.3 Free surface effect

Another very important aspect of fish hold design that is sometimes overlooked, or misunderstood, is that of designing the hold space to avoid the dangers of the "free surface effect". This is a potentially dangerous situation caused by unrestricted movements of large volumes of liquid from one side of a boat to the other, causing instability by a virtual rise in the centre of gravity (CG) of the hull. The same effect can also be caused by stowing wet fish, particularly pelagics such as sardine, in a hold with either no transverse dividers or penboards, or improperly installed penboards with excessive free space above the last or top boards. Partially loaded boats are more prone to this effect as there is the potential for much more free surface effect as the boat heels.

This same danger is also present if the vessel's fish hold or tanks are used for CSW. Without adequate thought and planning to prevent loss of freeboard when the tanks are filled, the range of initial stability available before the deck edge submerges under heeling forces is greatly reduced. Therefore, proper planning and design by qualified naval architects are critical if vessels are to pursue this stowage method. One of the options available to address the free surface effect of CSW tanks is the use of CSW sprayed continuously over the catch for chilling, eliminating the need for tanks.

Fishing vessels have been known to sink from the instability caused by partially filled CSW tanks or movement of improperly stowed wet fish from one side of the hold to the other. Figure 6.6 illustrates some of the dangers of free surface effect and how the installation of penboards can minimize its effect on vessel stability.

FIGURE 6.6
Free surface effect: half-full fish tanks or holds with and without longitudinal bulkheads



Source: National Fishing Industry Training Committee, 1983, and Canadian Coast Guard, 1980.

It is not within the scope of this publication to give detailed calculations for these effects. It is therefore very strongly recommended that a naval architect be consulted before and during any retrofitting of a CSW system to an existing boat. However, those wishing to know more on this subject may refer to Chapter 4 of Hind (1967).

6.3.4 Sanitation in fish holds

Sanitary requirements for fish holds in modern artisanal fishing vessels can be quite simply addressed if the following points are observed:

- Install the best insulation available (plastic foams) to prevent bacterial absorption and attack by vermin.
- Install a structurally sound impermeable lining over the hold surface that is non-toxic, durable and easily cleaned.
- Install a system for drainage of all waste, fish slime and contaminated meltwater to a central sump(s) from which it can be pumped overboard. Wastes must not be allowed to drain into the vessel's bilges.
- Institute and maintain a "ship cleaning" regime that is strictly adhered to, with specific crew responsibilities for cleaning each time fish are processed on deck and after discharge of catch in port.
- Keep an adequate supply of disinfectants, detergents, buckets and scrub brushes on board at all times.

In addition to the cleaning materials and instruction of crew in proper cleaning procedures, it is also necessary to have durable, easily cleaned liner surfaces in the fish hold, some of which are discussed in the following paragraphs.

Various types of linings have been used in fish holds and insulated fish boxes to provide a smooth, easily cleanable surface. The original method of fish hold lining in wooden boats is usually of wood plank or "ceiling" fastened to the inside of boat hull frames in the fish hold. This has the disadvantage of being difficult to keep clean without strong disinfectants owing to the wooden ceiling absorbing moisture, bacteria, etc. The smell of strong disinfectants could in some cases be transferred to the fish stowed in the hold. This being unacceptable, other methods of fish hold lining have been developed and used. Painting the wooden interior surface of fish holds with special paints has also been tried with limited success, but this is not a satisfactory solution as the paint is easily damaged, leaving the wood exposed to infiltration of moisture and contaminants as before.

Initially, zinc or galvanized steel sheets were used, fastened to the inside of the ceiling, the joints between sheets being sealed with bedding compound or soldered to prevent ingress of water and contaminated fish fluids. These linings allowed drainage of fluids to the bilge, where they could be pumped overboard at the crew's convenience. This type of lining is easy to keep clean but requires maintenance to maintain impermeability at such points as fastening holes and seams that can be damaged by shovels and boxes being moved around in the hold. Other disadvantages of some metallic linings are a certain amount of toxicity that can be encountered from zinc and some anti-corrosion products.

In many countries, fibreglass laminates have largely superseded metallic linings because of their ease of application and availability at reasonable cost. Their resistance to damage is also superior to that of thin metal sheet linings as there are no seams or exposed fastenings to be snagged by fish-handling equipment, provided of course that sufficient thickness of sheathing is used.

In the past, drainage of meltwater and waste fish fluids was in most cases simply allowed to find its way to the bilges, through unlined ceiling and floorboard joints, where most could be pumped overboard with the existing bilge pumps. Unfortunately, the remaining wastes become a microbial breeding place causing strong "off" smells that eventually affect the fish stowed in the hold. Direct contamination is also possible if the bilge contents are sloshing around in rough weather, as waste liquids filtered into the bilge through seams can also re-enter by the same route, especially if the bilge is not pumped regularly.

Coincidentally with demands for uncontaminated quality fish products, it was found that with the advent of good fish hold linings, it became possible to direct all drainage from the fish and ice to a central sump located in the hold floor low point. From this sump a dedicated pump discharges the wastewater overboard. This system is now standard practice on many fishing vessels worldwide; even relatively small boats (26 ft) can have similar systems. Other systems can also work. For instance, in some larger vessels a longitudinal grating is installed along the length of the hold. This is helpful if the floor is relatively level, as tends to be the case on larger boats, as wastewater etc. can enter the sump at any point and need not be channelled to a central sump. On other vessels, where there is a raised shaft tunnel running through the hold, it is normal practice to install sumps on either side of the shaft tunnel. The shaft tunnel should not be used as a sump.

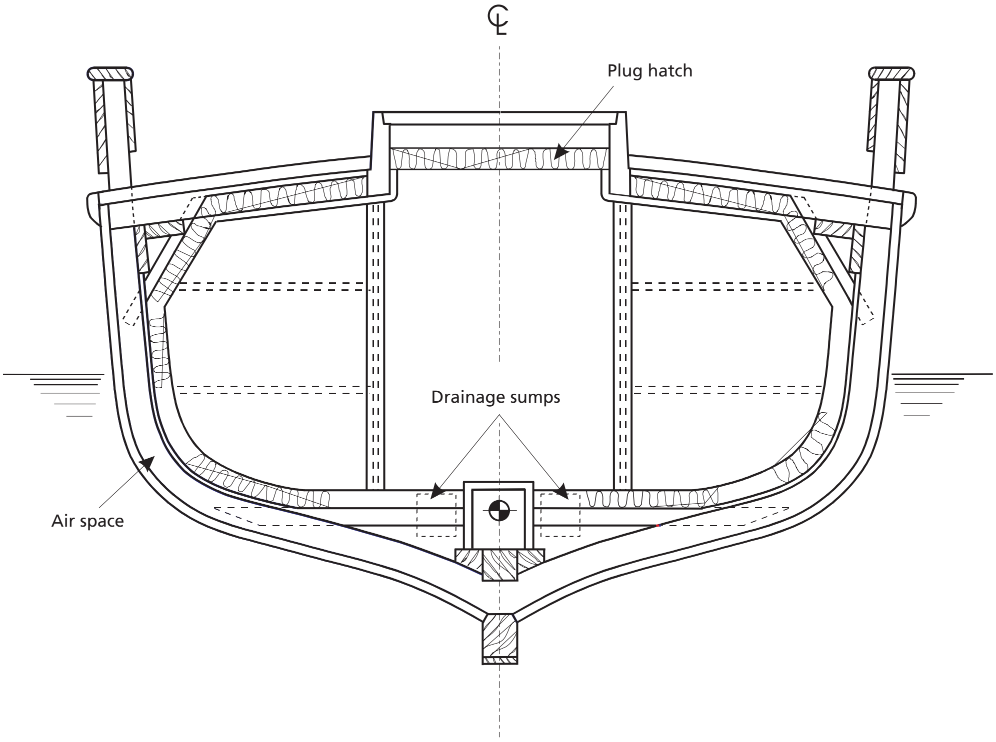
6.3.5 Insulation installation in older vessels

Many older fishing vessels were not built with insulation in their fish holds, usually relying on speedy trips to and from the fishing grounds, spending only a short time on the grounds to catch fish that were plentiful. This situation no longer exists in most fisheries. Today it is necessary to travel farther offshore and spend more time fishing for dwindling fish stocks. It is therefore very important to maximize yield from those fish that are caught, and insulation and ice are integral parts of this equation.

In most instances, when facing longer trips, it is calculated by the owners that adding insulation to the hold space in their uninsulated fishing vessel would be beneficial to profits. The owners' assumption will, in the majority of cases, be correct – the costs will generally be recouped over a reasonably short period from better fish prices at landing as a result of improved quality.

The majority of older fishing vessels are of wooden construction necessitating careful attention to the maintenance of ventilation in spaces behind the ceiling, in bilges and between frames to prevent accelerated rot in these locations. It is, however, reported by some owners of wooden vessels that application of foam by the direct-spray and foam-in-place methods in frame spaces and deckhead has reduced accelerated rot. These claims pertain usually to vessels operating in temperate or colder waters, so they must be viewed with caution, especially if a

FIGURE 6.7
Typical insulation installation for wooden fishing vessel



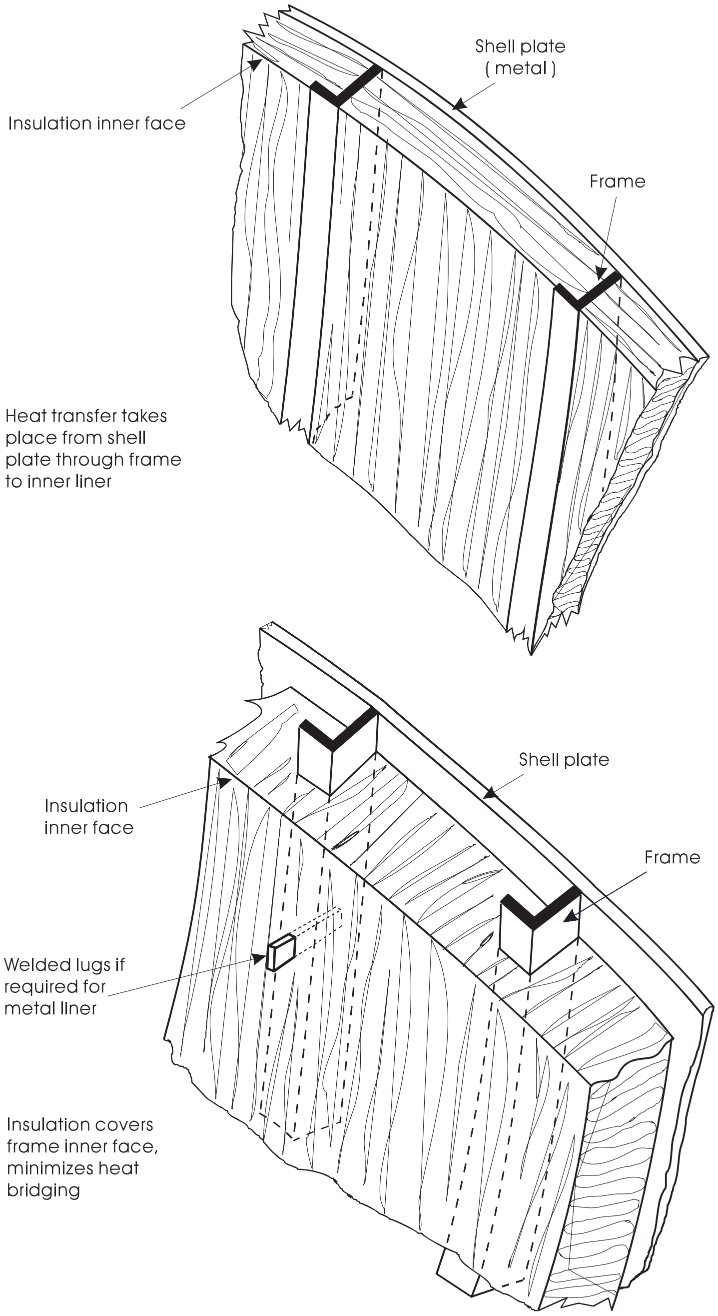
Cross-section of fish hold in wooden fishing vessel showing provision for ventilation between frames, ceilings and bilge.
Note ventilation arrangement at sheer clamps/gunwhale.
Two drain sumps on this vessel because shaft tunnel runs through fish hold. If shaft tunnel does not interfere, one sump is usually adequate. A common diaphragm pump can be used to pump out. Some vessels use electric pumps with attached strum boxes to prevent clogging.

Source: Adapted from FAO, 1988.

vessel is to operate in tropical conditions. A sectional view of a typical insulation installation on a wooden fishing vessel is shown in Figure 6.7.

Fishing vessels of metal construction are usually less problematic; they are easily insulated by spray foams, foam boards, pour-in-place foams or other materials, as available. There is a slight problem with heat bridging from the frames if the insulation does not cover them completely (see Figure 6.8). Completely covering frames to counteract this is the only option. If fibreglass or cement sheathing is to be used as a liner, it is not a problem. However, should the inner cladding be metal, it can be difficult to weld. The usual practice is to weld a series of discontinuous lugs onto the frames that protrude out of the inner face of the insulation. The metal lining can then be fitted and welded to these lugs as convenient.

FIGURE 6.8
Heat bridging through insulation on steel fishing vessels



Fibreglass fishing vessels are not particularly prone to problems related to installation of insulation. In fact, manufacturers of fibreglass boats tend to have supplies of two-part polyurethane foams as part of their inventories for use in some structural applications, buoyancy tanks and, of course, for insulating fibreglass boxes and containers that will be supplied with their own boats. Builders of larger sizes of fishing vessels will in some instances hire specialist insulation contractors who have all the necessary materials and equipment to execute the work in very short order. The increasing use of sprayed foam insulation in civil construction is giving boat builders easier access to insulation that is both good quality and economical.