Food and Agriculture Organization of the United Nations

FISH4ACP

Unlocking the potential of sustainable fisheries and aquaculture in Africa, the Caribbean and the Pacific

Tuna cold store feasibility study in the Marshall Islands

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german cooperation

DEUTSCHE ZUSAMMENARBEIT

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Executive summary

This report presents the findings of a feasibility study for the potential development of a cold storage facility for tuna fisheries in the Marshall Islands (RMI). The study was conducted for the FISH4ACP programme, which supports opportunities to empower more inclusive and sustainable fisheries and aquaculture value chains in line with the 2030 Agenda for Sustainable Development. The Marshall Islands is one of twelve locations across the globe identified by the FISH4ACP project which is an initiative of the Organisation of African, Caribbean and Pacific States (OACPS) contributing to the security of food and nutrition, economic prosperity and job creation through actions aimed to ensure the economic, social and environmental sustainability of fisheries and aquaculture value chains in Africa, the Caribbean and the Pacific. FISH4ACP is implemented by the Food and Agriculture Organization of the United Nations (FAO) with funding from the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ).

Exploring the technical feasibility, environmental impact and potential economic role of a cold storage facility on the Marshall Islands is one of a number of activities which FISH4ACP is assessing as an opportunity which could have the potential to improve local food security and employment opportunities, while safeguarding fish stocks and reducing the environmental footprint of the tuna purse seine sector.

Although this study is primarily designed as an impartial analysis without conflict of interest which scopes the potential feasibility of a tuna cold store, it has also been designed as a useful reference for local stakeholders, ranging from potential investors through to international donors such as IGO's who may be interested in understanding the potential options for upgrading tuna value chains on the Marshall Islands and require guidance related to their investment planning. With this in mind, the study explores existing similar interventions in the tuna industry, provides drafts of suggestive layouts and also provides information to support the development of modular technical designs which consider both long term sustainability, operational factors and depreciation alongside pre-operational costs such as training. This guidance also integrates concepts for innovative power and refrigeration systems including site specific (Majuro, the Marshall Islands) considerations for construction and thermal efficiency through to integrated use of renewable energy sources, all of which provide insight into the cost benefits and thus operational feasibility of a potential tuna cold store.

While this study is focussed primarily on the feasibility of a cold store infrastructure for tuna, it also raises aspects of resilience capacity building which crosscut other related interventions. This is because analysis of a cold store also encompasses many dimensions such as electrical power generation and use in terms of redundancy and consumption and also the potential for use of renewable energies. It also scopes improvements in construction and thermal insulating practices and other cost saving and value adding initiatives which may be relevant to other interventions.

To conclude this summary, this feasibility study has been made possible through the efforts of a range of specialists, and rather than presenting their outputs in isolation, they have been combined to form a more effective and understandable rationale for the solutions presented. It is also important to note that due to the nature of how a cold store integrates in tuna value chains, the outcomes and conclusions of this study may also be a useful resource to support other interventions, such as building capacity for containerization on the Marshall Islands or other hybrid solutions which borrow concepts and solutions presented in this analysis. This is particularly significant as analysis of existing refrigeration on the Marshall Islands (mainly containerization) plays a key role in determining the viability of the conclusions cold store feasibility study and solutions presented, particularly in terms of power and thermal considerations may benefit containerization. This is specifically the case on the Marshall Islands as the rationale for a cold store needs to be considered in comparison with containerization as there is no significant processing undertaken on the Marshall Islands. This differs to the usual case scenario when tuna cold stores are in close proximity to a significant processor such as a cannery and are deemed a feasible and implemented and operational for grading, sorting and storage to provide an on-demand supply of frozen tuna.

Background

A key objective of the Ministry of Natural Resources and Commerce of the Marshallese Government and the Marshall Islands Marine Resources Authority (MIMRA) is the vision to unlock further potential for the Marshall Islands' role as a tuna hub by upgrading the capacity to benefit from tuna resources in the region. It has been speculated that in ten years' time, this strategy has the potential to directly add value at an estimated USD 33 million from purse seine tuna fishing activities. In order to achieve these goals, one of the government's objectives is to develop opportunities to increase the capacity for containerization so as 30 per cent of tuna catches can be containerized. Identifying where a cold store facility can be a realistic positive benefit, integrated within the efforts of this vision, is also a key factor of consideration in the conclusions presented in this study.

A snapshot of the current scenario from the work undertaken in the FISH4ACP value chain study provides a useful baseline for this feasibility study, in that, although tuna accounts for almost all national fisheries production and exports from the Marshall Islands, increased catch in the region has not resulted in proportional domestic growth from post-harvest processing activities. FISH4ACP's value chain analysis, which provided a comprehensive background resource for this feasibility study, highlights that typically less than 5 per cent of catch is landed (currently containerized) on the Marshall Islands. Although there are clear opportunities such as improving post-harvest processing, sorting and grading of tuna, a broad range of factors require diligent analysis to determine the viability and function of how a cold store infrastructure could engage as a positive step to upgrading value chains through stimulating landings, benefiting stakeholders and improving the sustainable use of tuna resources on the Marshall Islands.

The critical concept behind this feasibility study for the Marshall Islands is that the cold store becomes feasible on the basis of an economy of scale, not only from a thermal perspective in terms of volume but also by empowering any opportunities for adding value and lowering operational costs.

Acknowledgements

This feasibility study for the Marshall Islands would not have been possible without the collaboration of the staff at MIMRA, and all the stakeholders who have been in constant communication throughout the drafting process of this document. Additionally, the support provided by the FISH4ACP management, team, and consultants, in particular the administrative staff, has been invaluable in ensuring this study and associated outputs were possible.

Methodology

This feasibility study for FISH4ACP evaluates the viability of a tuna cold storage facility on the Marshall Islands through a series of stages of analysis, each with a set of outcomes, each stage contributing to the next which synergise to rationalise a range of solutions for a tuna cold store on the Marshall Islands.

Existing tuna cold stores infrastructures

In this section, a range of current, recently constructed cold store facilities for tuna are assessed which have similar conditions to the scenario on the Marshall Islands. This analysis provides vital information based on previous challenges relating to issues faced in implementation and operation on a remote island scenario. Rather than focus on one particular type of approach, the range of designs and implementation methods provides a more diverse range of inspiration to scope options for the feasibility study.

Location feasibility

In this section, three potential locations for a cold store, which were identified in prior assessments and field surveys by both stakeholders and FAO consultants, are analysed and assessed in terms of both land tenure, capacity, logistical and other environmental considerations. An assessment of potential locations is critical, particularly as issues surrounding physical terrestrial space and land tenure is a key limiting factor on the Marshall Islands alongside potential risks due to future considerations for climate change.

Implementation feasibility

In this section, study explores the challenges of implementation in terms of construction of a cold store, analysing options for potential phasing for modular implementation while identifying challenges and providing best case solutions which are cross checked with the capacity to empower resilience and long-term sustainability of a cold store infrastructure. The solutions presented also include technical recommendations regarding infrastructure locations, refrigeration, power requirements and environmental assessments, including conclusions from a Preliminary Environmental Assessment (PEA). Considerations for climate change, which is of particular significance for the Marshall Islands, are also assessed including flood risk analysis and thermal recommendations. Analysis of implementation is a critical step in determining both implementation planning, quantification (and therefore an approximate idea of costs involved) and staging, while the conclusions of this evaluation provide critical information to analyse parameters for operational feasibility.

Operational feasibility

Based on the implementation conclusions, operational feasibility is analysed with considerations spanning economic, environmental, and socio-cultural factors to identify how a cold store could provide cost effective services which both raise added value for tuna while maintaining operational feasibility. This includes considerations for operation (particularly power requirements) and maintenance costs including structure depreciation, land leasing scenarios, and a range of human resources factors such as staff retention which need to be considered.

From an operational value chain analysis perspective, this cost/benefit section of the study also specifically assesses the rationale of such an intervention in terms of how cold store infrastructure could meet any existing stakeholder demands which are currently not being met. This process is critical in the validation of any responsible investment rather than a "build it and they will come" approach. However, the capacity of a cold store to upgrade value chains in terms of the potential to encourage and increase landings of tuna is also considered.

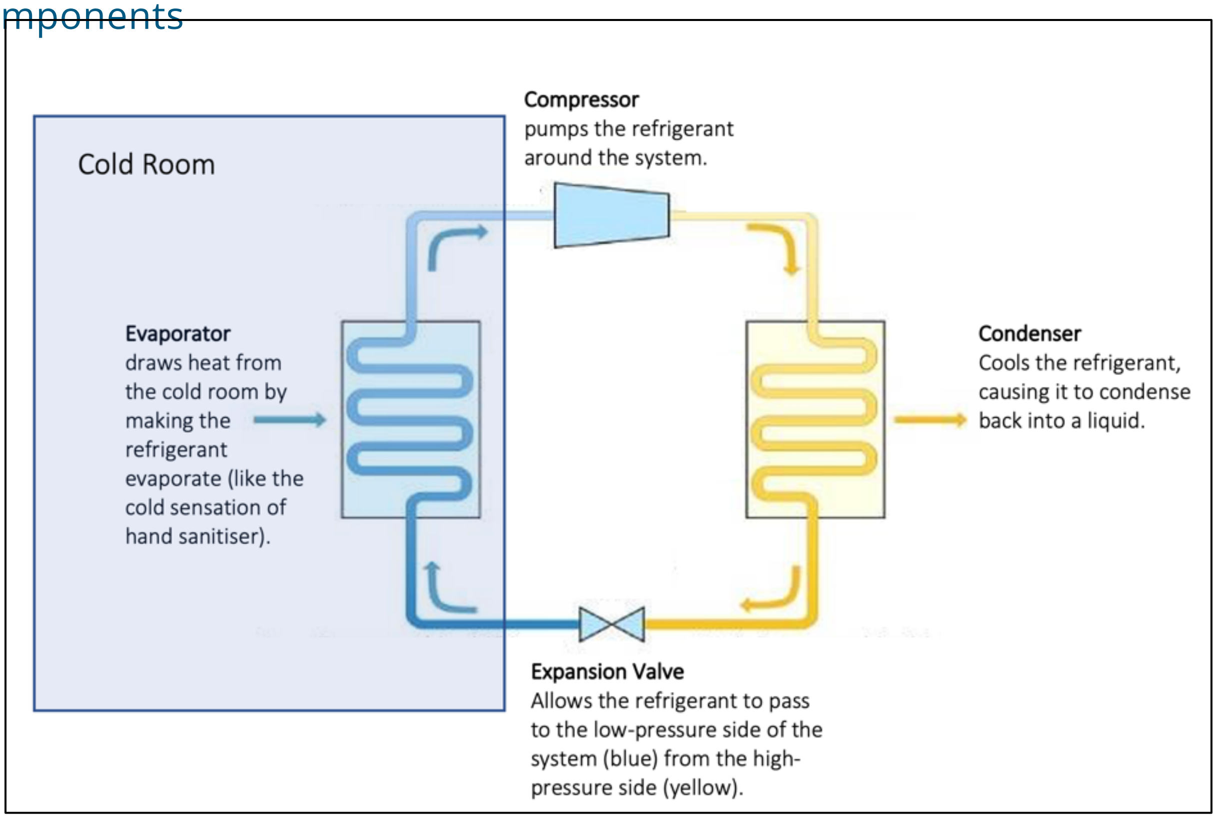
Methodology - conclusions

The outputs of all stages of analysis are summarised to present conclusions which offer an estimate of feasible economic parameters, guidance, recommendations, and a range of opportunities for exploring investment opportunities, implementation, and operation of a tuna cold store facility on the Marshall Islands. This is achieved through both a best-case solution which is scalable and modular but also variable quantity options presented in the outputs of the implementation feasibility assessment which allow a modular and scalable approach. However, variables in terms of quality of the cold store components which stray from the recommendations in this document will have adverse effects on operational costs, sustainability and also have significant impact on aspects such as maintenance and repair costs and real-world risks in terms of depreciation through decrepitude, of the investment. Conclusions presented are intended to encourage further discussions around the information provided in this study.

Background assessment of existing tuna cold stores infrastructures

In this section, we evaluate existing cold store infrastructures and examine how they maintain feasibility through investigation of design specifications, implementation, and operational characteristics. As previously highlighted in the executive summary, the typical location of cold stores for tuna supply chains tends to be in close vicinity to processing facilities such as canneries and these locations tend not to be remote islands, rather near key ports where carriers dock. This presents a challenge when attempting to identify current examples of similar scenarios to those on RMI and indeed, even those which can be identified, such as in Fiji and the Seychelles, do not have the same environmental considerations as are needed to be applied to construction on an atoll, as both have a relatively sheltered side. Despite this, there are some technical benefits which relate to the exposed aspect of the scenario on the Marshall Islands which relate to refrigeration, and these will be covered in more detail in the implementation section of this report.

Figure 1. Refrigeration - the basic processes involved and the key components



Following discussions and meetings with stakeholders, global FAO consultants and key members of the tuna industry, the three example sites to draw considerations from are identified as the tuna cold stores Kosrae (Micronesia), Suva (Fiji) and at Victoria (Seychelles). These provide a range of different scenarios for inspiration and variance in implementation, design and financing which is intended to provide comparative insight into the different approaches applied. The following sections examine each of the sites in more detail. It is important to note that some of the stakeholders involved in the locations were more forthcoming than others regarding sharing their experiences so the level of detail available varies for each example.

Da Yang Seafoods, inc. - Kosrae, the Federated States of Micronesia

The cold store at Kosrae, the Federated States of Micronesia is located at the commercial harbour, close to the airport runway and is operated by Da Yang Seafoods, inc. which also own their own purse seining fleet. The following information is quoted from primary sources at the time of writing. The cold store operation supports containerization activities in conjunction with frozen loin processing, sorting and grading and they state that they have a cold store capacity of 5000t capable of -30°C, with HACCP and BRC Food certification alongside nine MSC certified products. The cold store supports these product lines, and the operation aims to expand its capacity to include a further processing plant for the European Union certified tuna loins in the near future.

The company has a clear set of values on its website which span from Human Rights based approaches across to demonstrating its integrated public private partnerships (PPP) and associated cascading economic benefits. They also state that their annual payroll is over 1 million USD and have over 120 employees which sets the average income per staff member at just over USD 8 000 per year. However, on closer scrutiny of their profit and loss documentation, for 2022, their payroll accounts are considerably higher, currently at around 5 million USD indicating that salaries may be considerably higher. Considering inflation since 2002, this can be compared to the Kosrae State Census Report (2002) which states that median household income across municipalities ranged from USD 8 700 (Lelu) to USD 4 800 (Utwe) and aligns with the ethos which is clearly stated by Da Yang Seafoods regarding their vision for PPP, sustainable fisheries and post-harvest management, education and diversity, staff capacity building, food safety, health and safety and commitment to thinking for the long-term future.

The supporters of the project “We Believe in Kosrae” include Port of Korsae, DRE/KIRMA, the Office of Kosrae Governor, the Office of Senator Joe, the City of Tafunsak, NORMA, Invest Kosrae, Speaker of Kosrae, the FSM President and the PNA. As with all the sites reviewed in this section, no UN agencies were involved in supporting the project, and perhaps hence, no association with the 2030 Agenda for Sustainable Development appears in any of their publications or documentation. This can be seen as a missed opportunity to support an effort with clear signalling aligned to the SDG’s however somewhat lacking in terms of explicitly addressing gender issues, although diversity is a key attribute of their agenda. In terms of technical assessment, no information was made available as to specifically what refrigeration equipment was used, or panelling type/methods, or other key infrastructure other than brand names of Akiyama/MK (Japan) and Nigata (Japan, typically generators) technologies which were imported. This indicates that high grade, including Japanese technologies, may have been used for other components. From available photography of the facility, it appears that 150mm panelling was used for the roof and walls with estimated characteristics of PIR density: 42±2 kg/m3, and a fire rating of B1.

In terms of construction, the most critical factor regarding the facility at Kosrae is that the location has some similarities to the locations identified in the atoll scenario on the Marshall Islands compared to Fiji and the Seychelles. This is fundamentally that the cold store is very exposed to ocean on all sides, and this plays a critical role in efforts to mitigate depreciation due to corrosion from sea salt aerosol (SSA). Although the characteristics can be seen as detrimental, the scenario of being very exposed to ocean wind has some key benefits in terms of refrigeration which will be explored later in this study.

The facility design also integrates an efficient and fast conveyor system to feed sorting, grading and processing activities which also compliments containerization, which remains a mainstay in playing a critical role in transportation of commodities. Perhaps the main attraction of the efforts of the Da Yang project is that they have a vision for accessing international markets from the Pacific, particularly their goal of achieving loining processing certified and destined for the European Union. Supporting these efforts should be a key consideration in terms of their discussions with stakeholders on the Marshall Islands showing interest in developing a cold store and other processing facilities and, in consideration of their overall ethos, is perhaps the main takeaway to be gained from this analysis and should be considered a key stakeholder demand in terms of justifying the feasibility of a cold store which compliments upgrading of containerization capacity on the Marshall Islands.

Foods Pacific inc., Rokobili cold storage - Suva, Fiji

Foods Pacific inc. consists of three limited companies, Tripacific Marine Limited, Pacific Feeds Limited and Rokobili Cold Storage. Tripacific Marine Limited consists of a fleet of fishing vessels stating that it has “unprecedented access to some of Fiji's finest fisheries”. The company states that it uses sustainable fishing methods with special care for environmental concerns, to produce high quality yellowfin tuna, albacore tuna and wahoo products for export. The company's Suva processing plant is HACCP and FDA approved, stating that it also has international and European Union approval for exporting tuna from Fiji to Europe. Tripacific Marine also exports sashimi tuna loins to Japan and also processes tuna for other major international tuna suppliers including production and export of ready meals, value added tuna products and foodservice products, in conjunction with Foods Pacific Ltd. Pacific Feeds Limited specialises in pelleted food products for poultry, pigs, dairy, duck, prawn, and fish foods with distribution throughout the South Pacific Islands. These two companies synergise with Rokobili Cold Storage which is 5000 Mt in capacity and is the largest cold storage facility on Fiji capable of -30°C with floor to ceiling racking and computerised inventory control systems. Storage space is rentable by volume for commercial customers and is not limited to use as only for storage of tuna.

Although this cold store is not dedicated for tuna stocks and processing alone, it provides an example of how a cold store can also provide services for other food sectors which may be a critical consideration in terms of the feasibility for a cold store on the Marshall Islands in that other food commodities could be stored, for example vegetables. As with Kosrae, the viability of this value chain is integrated into a business infrastructure which incorporates fishing vessel assets, processing, and branded, certified commodity export, besides containerization.

Central common cold store - Zone 14, Seychelles

Prior to 2014, Sapmer, a tuna fisheries company based in Réunion and Mauritius which started in 1948, was only loading in Mauritius because they were focussing historically on premium tuna, rather than skipjack and yellowfin in brine, and freezing the tuna at -40°C requiring specialist personnel and manual handling procedures which take time for unloading. At the time the company started, the Seychelles did not have a lot of port logistics which limited capacity for operations, so Sapmer considered it easier to operate out of Mauritius. However, calling back to the port in Mauritius with the catch from the Seychelles would take around four days to get there and four days back to the fishing area resulting in a monthly loss of around 8 days resulting in logistical inefficiency. As the range of product developed, in 2014, Sapmer decided to investigate opportunities to offload their catch in the Seychelles and began discussions with the government and ministries of the Seychelles to try and devise a solution, initially developing the port, and following this, a 12 800 Mt cold storage facility as a public private partnership, the Central Common Cold Store (CCCS).

Although the port facility was a key initiative for Sapmer, the desire to implement the CCCS was driven by a broad range of stakeholders as Sapmer only required one cold room out of the 12 rooms which make up the entire volume. Key brokerage points of the CCCS business model for both feasibility and investors is that it achieves economic functionality as system of renting space, rather than fish. This approach, combined with high efficiency in power consumption and thermal design creates an economy of scale which is highly competitive compared to alternative storage options such as containerization. Additionally, the CCCS does not depend solely upon a client which processes in close proximity to the store but rather a range of clients and although there is a Thai Union cannery on the island which utilises 40 percent the storage space, the remainder of the space is utilised by a broad range of clients and Sapmer, including around 25 percent being used by Spanish companies.

The current key function of the CCCS is operating as a controlled environment for sorting, grading and stock holding during price fluctuations, while also enabling more specific orders to be containerized. In this sense, the cold store currently operates purely as a sorting, grading, and storage facility. Unlike the previous two examples of Kosrae and Fiji, the Seychelles presents a much more similar scenario to the Marshall Islands in terms of containerization volume handled prior to the implementation of the CCCS cold store. To put the impact of the CCCS into context, before the store was built, containerization was only at around 200 containers per year however, since the cold store has become operational, this figure is at around 8000 containers per year, demonstrating the cost effectiveness and added value through services which the cold storage facility provides.

One of the key challenges which CCCS provided a value adding solution for was to mitigate lower sales values of containerised bulk sales to processors due to sorting and grading capacity. To elaborate on this, an example scenario is that they would sell 20MT of sorted tuna to the cannery in bulk and they would be within this quantity, 18MT of a specific desired species/ grade/size and the cannery would only pay for the 18 Mt, and not the 2 tonnes remaining because they had no use for it in terms of optimising their production yield. To summarise, the sorting and grading facilities at CCCS have resulted in around 10 percent higher returns in the sales of containerized tuna and added to this, sorting in a controlled environment, rather than on the dock or vessel, has, in this scenario, improvements in the quality of the product, particularly when the ambient temperature is around 30°C.

Another driving factor to improve the capacity for sorting an grading to meet demands of buyers to optimise production yields appears to be the European Union Control Regulation on quotes of yellowfin tuna and, in particular the Eeuropean Union control regulation on margin of tolerance imposing that there is a difference of no more than 10 percent per species between the estimates on board and the actual landed catches, legislation which has caused well known anguish for the French fishers who highlighted that sorting at sea at 30°C would result in increase in post-harvest losses through histamine build up.

To elaborate more on the production yield value adding scenario, because the fish is all bulk when it is on the vessel, it is challenging for the buyers and processors to procure the specific stocks which they need to meet their orders downstream in the supply chain, so they would for example, request that they require skipjack between 2kg and 3kg because for a specific order, as this would have the optimum production yield. However, unlike some of the larger Spanish vessels which return to port to undertake sorting activities, Sapmer vessels do not have the facility to undertake this level of sorting and grading on board the vessels, and so this raised the precedent to build a cold store facility to undertake these tasks in a more hygienic, controlled environment. An additional aspect which also adds value for potential space renting clients is that landing, grading, and sorting in a controlled environment enables validation of any traceability parameters required for products, to be implemented. This is the case with several clients currently using the CCCS.

A key aspect which enabled these added value characteristics is the careful considerations that the CCCS team planned for the construction design, power supply efficiency and the integration of renewables in the refrigeration system. These characteristics have enabled more thermally efficient and cost-effective storage than other alternative solutions, such as containerization, to the extent that holding stock during price fluctuations is both financially viable and profitable.

Although Sapmer implemented the entire construction of both the port facility and the cold store, they only own approximately 40% of the port and CCCS and the remaining 60% is divided between investors including the construction company which built the CCCS owning 10%, the Government of the Seychelles 10%, an insurance company 10% and the remainder is owned by other companies and bodies including options for locals to buy shares in the facility.

"For the first time, the Seychellois will be given the opportunity to significantly invest in the tuna industry sub-sector and in the proposed CCCS project Seychellois is destined to have 51% shares on offer… The Central Common Cold Store (CCCS) has announced that its share issue has been oversubscribed by 35%, showing the very positive response from investors, with more than 200 Seychellois, individuals and companies applying for allotment in shares." (Seychelles Nation, 2017)

In 2017, the steering committee finalised the conditions and precedents required to be fulfilled during allocation of shares were that the following were confirmed:

- Lease agreement signed on land allocated to CCCS.
- Definitive approvals for autonomous production of energy and water were confirmed.
- Binding commitments for 75% of the 12,600 tonnes storage of capacity for a minimum of 3 years.
- Signed rent agreement for processing and other services area.
- Signed term sheet for the bank loan with clearly identified closing conditions.

It is clear that these interventions have created a significant benefit, both in terms of logistical efficiency for Sapmer and also for a range of other stakeholders, however, there are also clear economic benefits for the Seychelles in terms of blue economy development, not only through investment, but also local employment which is currently at around 200 staff. Since the CCCS became operational with two key lines of service, sorting and grading, and storage, they are now running near full capacity and are now seeking to develop a third service line in 2023 by beginning to develop processing activities. A key takeaway message from the development team is that having a dedicated and cohesive team has been essential in achieving this success, and that the concept of an economy of scale has been key to the Central Common Cold Store.

The total cost for the CCCS project was in excess of $37 million USD and much of this was anticipated prior to the outbreak of COVID-19. As the project spanned the COVID-19 outbreak, it is clear that a similar scaled project now, would cost considerably more. As an example, the cost of tuna storage bins allocated in the original budget plan was around $0.5 million USD, however, as these were procured later, the actual cost was around $5 million USD. This type of challenge which the CCCS team overcame highlights the level of elasticity required in terms of the rationale for the business plan and the level of dedication to complete the investment.

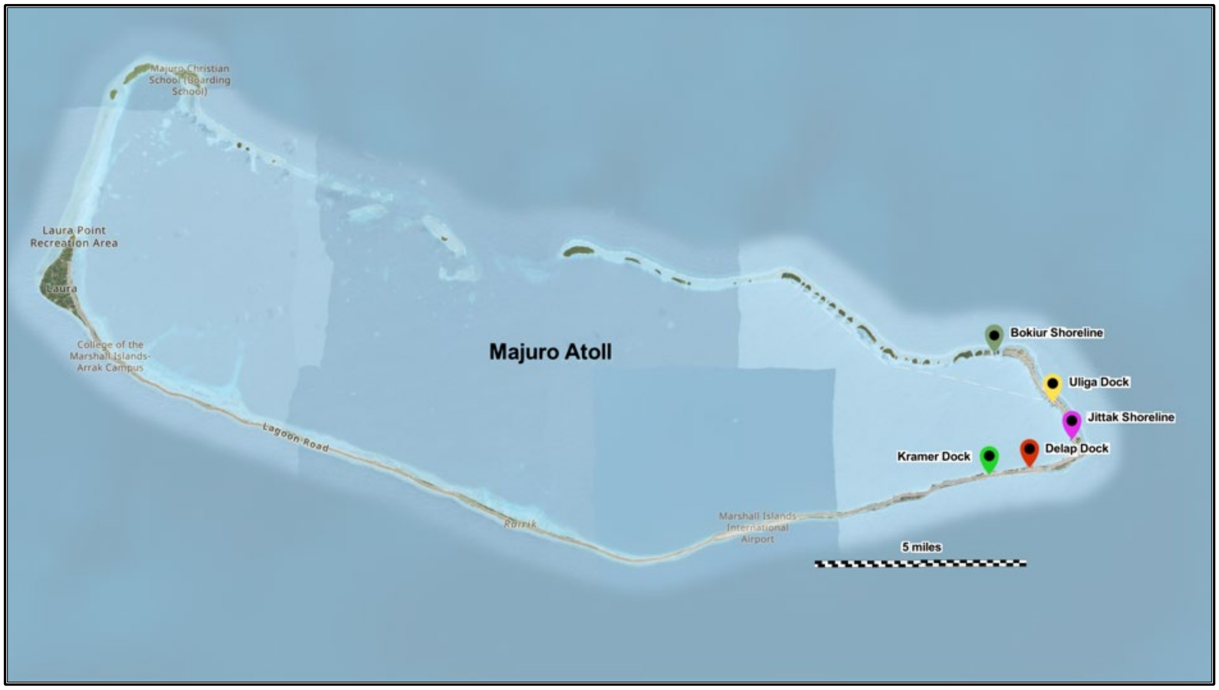
There are a range of technical implementation and operational characteristics from the CCCS which are key to its operational efficiency. These characteristics will be addressed in the following sections of this study and are critical considerations in terms of both minimising operational overheads and infrastructure depreciation and should be considered highly critical to the feasibility of a potential tuna cold store on the Marshall Islands.

Background considerations

One of the fundamental characteristics of a feasible tuna cold store which interacts with fishing vessels and carriers is efficiency in logistical operations. This is clearly related to the cold store's proximity to docks where fishing vessels can reliably offload catch onto conveyors to tuna bins (sometimes also referred to as scows), and where containers can be stuffed and moved efficiently to be lifted (by crane/gantry) onto carriers. In many scenarios, where dock infrastructure is limited, there are challenges which relate to the speed of unloading, as dock space is competitive, and typically, carriers often take preference overfishing vessels. Any resulting delays and slower offloading speed for fishing vessels results in less time at sea undertaking fishing activities. For this reason, a dock location which has less priority for carriers, or dedicated space for fishing vessels, is highly preferable. While some readers may already have identified a location, the information in the following sections is still useful, as the rationale for rejecting locations is critical reasoning which reinforces the key characteristics which enable a cold store to be feasible.

Five potential locations for a cold store facility were identified by FAO consultants from prior knowledge and through FISH4ACP value chain analysis interviews carried out in 2020-2021 in collaboration with the MI-FISH purse seine tuna value chain upgrading strategy of the Republic of the Marshall Islands. These locations range from sites with existing dock infrastructure, sites expanding docking infrastructure and sites with no dock infrastructure. During consultations with MIMRA, they also indicated that it may be an option to expand fishing dock operations infrastructures in the future to other islands, besides at Majuro, as this could potentially expand the range of fishing operations and operational efficiency besides other factors. However, for this study, we focus on the five potential sites identified on Majuro at Bokiur Shore, Delap Dock, Kramer Dock, Jittak Shoreline and Uliga Dock.

Figure 2. Map of the five sites proposed by FAO consultants as prospective locations for a cold store facility on the Marshall Islands



Source: GIS data - ESRI Mapviewer

Cold store footprint and tuna bins

Prior to the step-by-step assessment of sites, it is critical to define the required footprint of a cold store facility. This is a key predetermining factor which has the capacity to override factors such as proximity to port infrastructure. Although the contemporary approach to building storage is to "build taller" than traditional 40ft cold storage, tuna cold storage has some challenges relating to limitations in the height of the structure as tuna is stored in stacked steel bins. Building high cold storage results in greater thermal efficiency from the roof, where solar radiation is a critical factor in operational expenditure (OPEX).

Typically, the bins are approximately 1.7m long x 1m wide x 1m high and the stacking height of the steel bins is limited due to a number of factors.

- Both the mass of the tuna, the stacked bins, and the capacity of the bins to withstand the overhead load vertically.

- As we have seen from the CCCS example, where the rooms are around 9m high, and stacks of 8 bins are possible, the bins have a significant cost as cheaper bins are not capable of withstanding the mass. N.B. Bins are expensive, and pricing fluctuates. They are also expensive to ship!

- Added to this, is that the more that the sides of the bins are open, the higher the efficiency of the cold store in terms of removing thermal energy from the tuna, and so keeping it cool. This is achieved by the sides of the bins having either gridded mesh or holes, improving the efficiency of the cooling capacity, however this reduces the stacking capacity, or increases the cost of the bins.

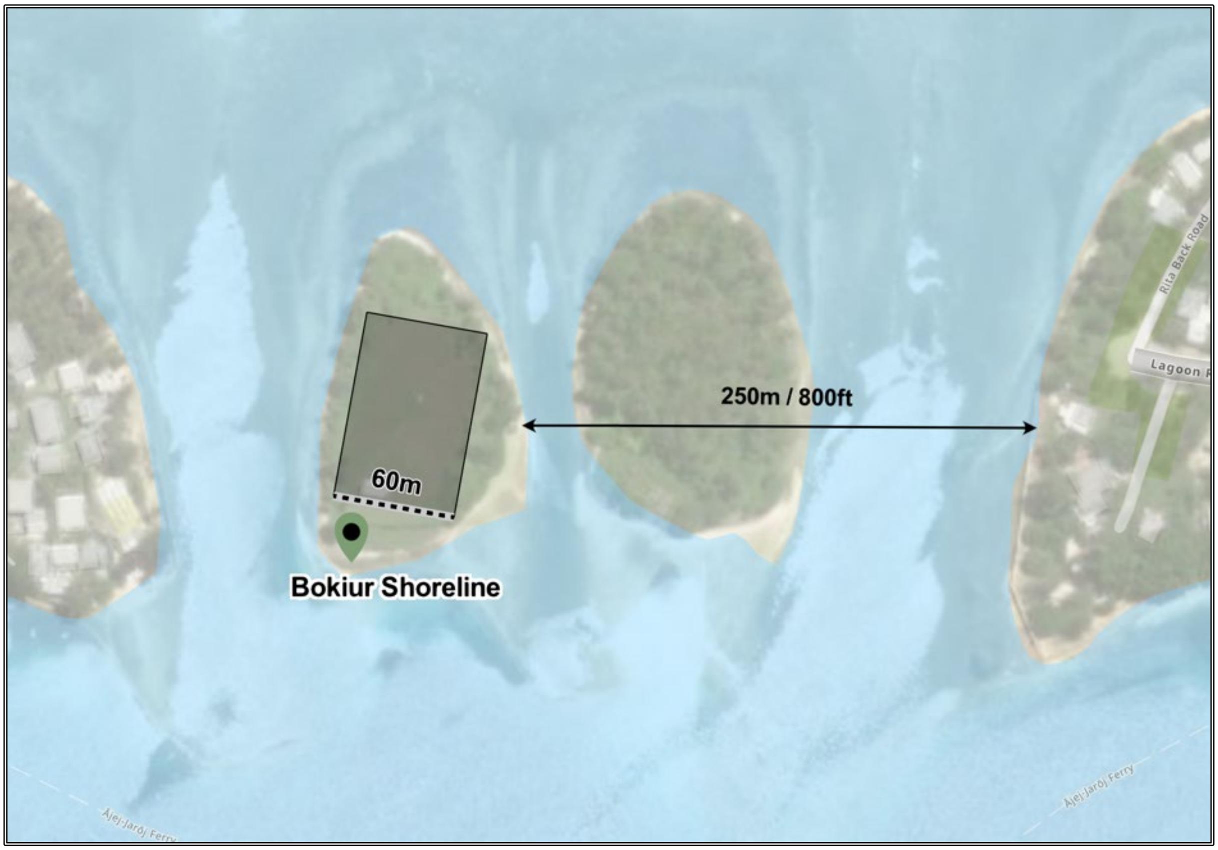
With operational costs in mind, as we have seen with the CCCS, improving the thermal efficiency of the cold store is critical to its feasibility so building the rooms as high as possible typically results in a limit of a 9m ceiling height, and at this height, an approximate conservative estimate of around 0.5MT of tuna per m2 can be used to calculate the footprint for the various locations without drafting designs for each specific location. This calculation also accounts for logistics areas for machinery such as forklifts and doors, loading bays, sorting and grading area, generators, and plants/generator rooms, i.e., the main construction volumes, but does not account for logistical space to and from a dock. This additional logistical space (which will be referred to in the following location analysis section) is critical for the feasibility, and while we will focus on this footprint calculation as a guide, it is critical to remember that a nearby area for containerization to stack containers is vital for any cold store operation on the Marshall Islands. Using 0.5m2/MT as an approximation for the cold store footprint, with this estimate, a 3000MT cold store could have a footprint of around 100m by 60m and a 1000MT cold store, a total footprint of approximately 65m x 30m. While these figures are useful, the economy of scale concept should be closely observed, in that, the larger the facility, the more cost effective it becomes and the less m2 it occupies per MT of tuna capacity.

Besides the functional fundamental characteristics of this footprint, despite being limited in height due to stacking limitations it is also critical to understand that a larger footprint also has key benefits. Effectively these benefits are that it results in greater thermal efficiency as exposure to ambient temperature is less by a cubic (x3) relationship as volume increases (key considerations for an economy of scale). Additionally, a larger footprint increases roof space which can be used for photovoltaic solar panels (PV) and catchment of rainwater. These characteristics will be elaborated upon in the implementation and operational sections of this study.

In the following sections, each of the locations identified is analyzed to address potential for a cold store to be implemented. For each location, the following specific criteria are assessed, cold store footprint, land tenure, logistical characteristics, physical characteristics, access to services, and pipelined investments and development. Land tenure is a critical factor in this analysis as this condition is important to determine security (e.g., quitclaim deed) and adequacy of land for investment, making this a fundamental condition will not only avoid delays due to property disputes but could also entail the potential for land to be collateralized by landowners and/or lease holders to support financing needs. Another compounding factor relating to land tenure is that, ideally, should a cold store be implemented, it should have a modular approach and where space is limited, potential expansion is also compromised.

Bokiur Shoreline

Figure 3. Map of the suggested site at Bokiur shoreline and distance to the main island



Source: GIS data - ESRI Mapviewer

The area identified at Bokiur Shoreline consists of a rectangular plot approximately 0.5 hectares in size, and dimensions of around 60m by 80m. Although this land has theoretical potential for a small cold store facility of around 2000MT, there is very limited additional space available for logistics to and from a dock, which also currently does not exist. Both these factors fundamentally flaw any proposal. Bokiur Island is only accessible by boat (or by foot at low tide) from Majuro proper and the island is largely stripped of vegetation to accommodate for the cellular antenna tower in the middle of the island which would need to be moved if a cold store was implemented. In terms of power, the island does lie along a submerged electric utility line.

Finally, an additional complication is the lack of municipal water supply to the island, which, although this could theoretically be piped as, although reverse osmosis could be an option, the cost effectiveness of this process is an additional burden on OPEX. Overall, the limited space and lack of dock infrastructure mean this location proposal is rejected, there are also additional considerations for flood risk and also the condition of the substrate relating to construction requirements which potentially would be highly questionable.

Uliga Dock

Figure 4. Map of the Uliga Dock location showing the main suggested site location in the red polygon and the disused bowling alley, defined within the yellow polygon

Source: GIS data - ESRI Mapviewer

Two areas were proposed for assessment in the vicinity of Uliga Dock, one being an area of approximately 4000m2 adjacent to the dock (red) located within the existing MISCO Wholesale and Retail establishment, and the other being the region occupied by a disused bowling alley (yellow) of 1500m2. Besides being obscurely small, the bowling alley site does not offer any particular logistical benefits, and both are also located in a urban area which raises issues such as noise pollution from a cold store. Even with significant acquisitions of adjacent properties which could prove complicated, the dockside location is only 0.4 hectares and would only be capable of hosting a cold store of around 2000MT with no space for modular expansion and logistical area for containerization. For these reasons, this location has been rejected.

Jittak Shoreline

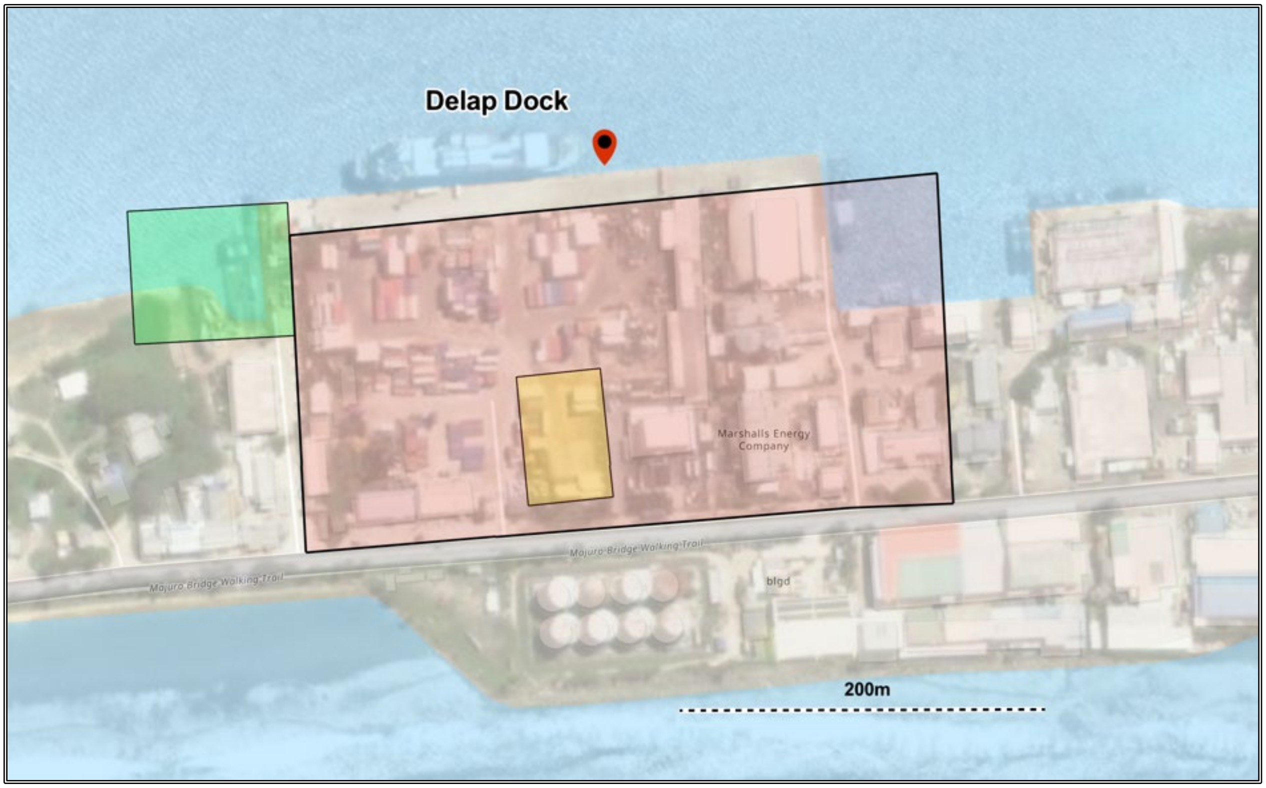
Figure 5. Map of the proposed location at Jittak Shoreline defined by the purple polygon.

Source: GIS data - ESRI Mapviewer

The location proposed at Jittak Shoreline comprises of an area of reclaimed land from a former dredging site which is 2300m2. This area lacks dock infrastructure and would also only permit a very small 1000 Mt cold store to be built. Building a cold store on reclaimed land also raises key structural questions relating to the substrate which would require further technical investigation. FAO consultant Mark Stege also concluded that no formal interest has been expressed by property owners for consideration. Logistical space for containerization or expansion of a modular approach is also limited at this location. For these reasons, the location isn't considered a viable option.

Delap Dock

Figure 6. Map of the proposed location at Delap Dock



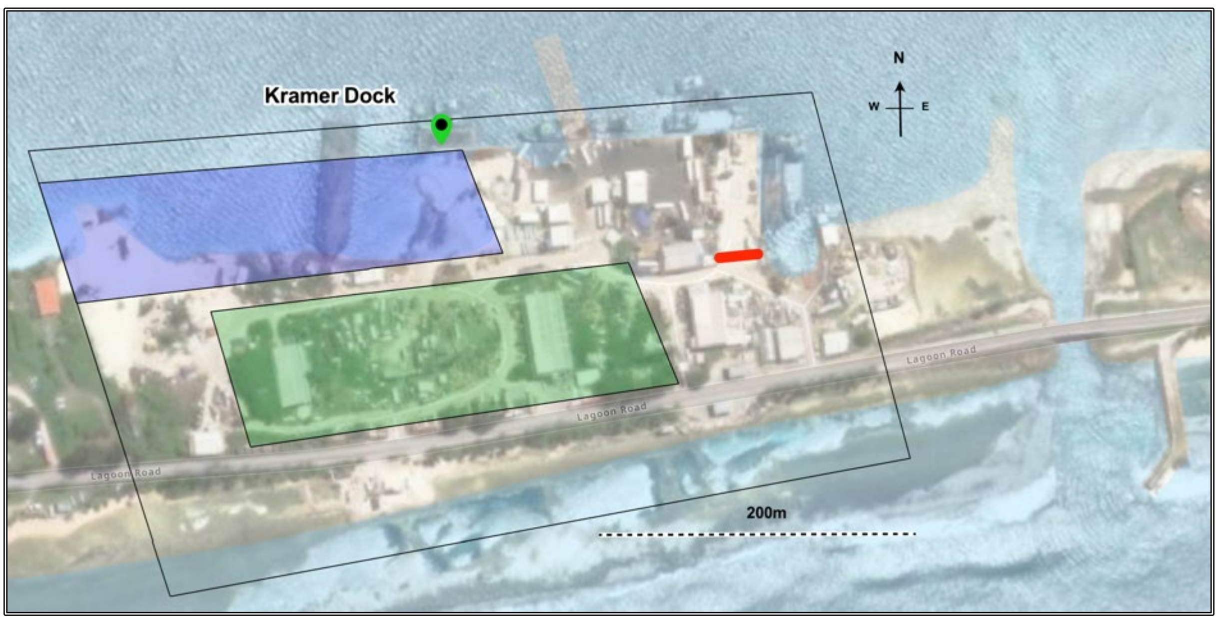
Source: GIS data - ESRI Mapviewer.

In 1974 Majuro traditional landowners of the property encompassing Delap Dock issued a quitclaim deed to the Marshall Islands Ports Authority (RMIPA). The quitclaim extends another 100 meters westward of the current Delap dock, and 250 meters eastward. Currently, Delap Dock does not have adequate space for a cold store facility as increasing activity over the years by Delap Dock users and service providers have led to conditions where competition for space is high both within and around Delap Dock. To put this in perspective, within the red polygon, measuring about 4.5 hectares, are various buildings and facilities owned and/or operated by the Marshall Islands Ports Authority, the Majuro Stevedore and Terminal Company (MSTC) container yard, Tobolar Copra Processing Authority, and Majuro Power Plant. Nearby operators and stakeholders also include the Ministry of Works, Infrastructure and Utilities (MoWIU), the Marshall Islands Sea Patrol, Pacific International Inc, Pan Pacific Foods, MIFV, Koos and MIFCo, MIMRA, and the Ministry of Finance (MOF) Procurement Division. Within the yellow polygon, MSTC keeps its 43 reefer container plug-in points connected to the main grid. MSTC also maintains a 20-foot converted container with 38 plug-in points used as a backup generator during extended power outages.

Besides the combination of infrastructure services, some logistical bureaucracy and complexity of shared space, the dock itself currently has limited capacity and is also typically prioritized, for carriers, rather than fishing vessels. However, there could be the option of the RMIPA to make space by exercising its controlling interest under the quitclaim towards a 100-meter westward extension, as shown in green polygon. However, this extension is not presently envisioned to prioritize the MI-FISH upgrading strategy aims and objectives, much less is it financed. Additionally, construction considerations for building a cold store on reclaimed land raise technical issues which span both more complex structural and environmental assessments.

Kramer Dock

Figure 7. Map if the proposed location at the Kramer Dock



Source: GIS data - ESRI Mapviewer

In terms of land tenure, it is unclear what type of ownership or leasehold status the Kramer Dock falls under. However, for the purposes of this study, it appears that the Kramer family enjoys at least unfettered usufruct rights that permit the mining of surrounding underwater rock and aggregate, land reclamation works, and the development of the Kramer Dock. The boundary of this is estimated to be shown by the black polygon as these land use rights appear to begin on the western end of the Majuro Bridge and extend up to neighboring properties, the total range of this space being in the region of 0.5 km long.

The Kramer Dock provides critical services to vessels in the region, including purse seiner (PS) support service equipment on site including net repair, an equipment repair workshop with capacity to repair prop shafts, one container handler, one forklift, five container stands and shoots, and a flatbed truck needed to haul each packed container to the Delap Dock about 1.5 kilometers away. The MSTC flatbed truck is also regularly hired to transport refrigerated containers to and from the Kramer Dock. Security and public health regulations maintained by the RMIPA establish the dock apron as a restricted area whenever there are PS operations taking place (the RMIPA security check point is demarcated by the red line on the Kramer Dock map).

It is evidentially clear that while Delap Dock is already maximized in terms of use of space, the Kramer Dock has the potential, and aims to, become a dedicated dock for berthing and containerizing tuna catches from PS tuna vessels, consistent with the MI-FISH upgrading strategy, allowing a secure dock for berthing and containerizing catches from PS tuna vessels in support of fulfillment of orders placed by Walmart through Pacific Islands Tuna Provisions (PITP).

Following various meetings and field surveys, the green shaded area on the map was identified as a possible location for development of a cold store. Measuring approximately 2.0 hectares, on non-reclaimed land, this area has ample space to facilitate a cold store in modular form with all associated infrastructure such as an area for containerization activities. It is important to note, that at the time of writing, available satellite imagery has not been updated and the existing dock, currently 170m in length, is now being extended westward which is intended to allow for additional docking space directly in front of the cold store location. This extension plans to build along this same trajectory include extending the Kramer Dock an additional 250 meters westward (the blue polygon on the map), and besides docking capacity, this is intended to enable more efficient sorting and container loading equipment, and the possibility of construction of a cold store facility with sorting and grading infrastructure. From the range of locations presented, the Kramer Dock stands as the most optimum for implementation of a cold store. Besides the rationale presented in this section, there are a number of key technical reasons why the Kramer Dock is also favorable which will be presented in the following sections covering implementation and operational feasibility.

Implementation feasibility

Introduction

The key takeaway to effective and feasible design of the cold store is to constantly revisit that keeping operational cost to a minimum, while maintaining low depreciation, and high efficiency is critical. To this effect, the feasibility of the cold store is largely dependent on the concept that it is an economy of scale. This is particularly the case if compared to alternative methods of freezing, such as containerization. With the concept of economies of scale in mind, we start by formulating options for a modular design for a cold store, which can be scaled up through future expansion, from the inside out. To proceed, we will begin by analysing some very basic logistical parameters relating to stacked tuna bins.

Figure 8. Frozen tuna stored in a tuna bin

Defining the cold storeroom space

Cold room height

Cold room height is critical in maximising efficiency, both in terms of maximising the footprint of the land used, but also in terms of thermal efficiency. Taller cold rooms, as previously mentioned, have less surface area exposed to solar radiation, and less thermal transfer to the ground. This can also be mitigated by having a void space between the non-refrigerated ceiling of the cold store and the main roof structure. Roof design is a topic which will be covered more in depth in the electrical power section of this study as, in the case of the Marshall Islands, a recommendation is that a superior (upper) roof should be designed and orientated to maximise energy from a substantial solar array.

Isles, forklifts and tuna bins

There is an underlying rationale in terms of determining the size of a cold storeroom which is related to the size of the forklift required to lift the tuna bins. This determines the isle width which is effectively empty space. Although this void is critically necessary logistically for the cold store to function, the rationale is that it becomes a less efficient volume as the room becomes smaller, as no matter the size of the room, the isle remains the same size.

Figure 9. Inside one of the cold rooms at the CCCS Seychelles

Source: CCCS Seychelles

However, there is a limit to the depth to the side walls of the capacity of the stacked bins, as access to stocks also becomes more logistically difficult with a forklift as the stacks become deeper and the cold store fills to maximum capacity.

Ideally, forklift prong length should be short both due to weight (mass) of the bins and the size of the forklift, which should be small, which also determines the minimum isle width. Minimising this void per MT of fish stored, while maximising logistical access to the bins, thus becomes a critical trade-off.

Figure 10. Forklift operating tuna bins at -40°C, Japan

There are many safety and risk assessment dimensions associated with forklift operations however, they must be addressed and in the case of a tina cold store, adequate thermal protection such as a closed and heated cabin is an essential priority particularly as the gradient between internal temperatures of the cold room and the external ambient temperature of the Marshall Islands is so great, resulting in physiological stress to the operator should they not be adequately protected.

There is also a refrigeration consideration which comes into play in this scenario, and this is that for the stock to be chilled at the required temperature, air flow needs to be as evenly distributed as possible throughout the stock, and, depending on the design, the isle plays a role in terms of this process as it allows airflow between the two sides of stacked bins. This also contributes to thermal efficiency and the work the refrigeration system has to undertake to keep the stock refrigerated.

Key takeaways - isles, forklifts and tuna bins

- Isles need to be logistically wide enough for forklift manoeuvres.
- Forklift procurement should include a full risk assessment and technical specifications should include a closed heated cabin.
- Isles play a critical role in terms of air circulation and evaporator fans should be placed high, at one end of the isle.

Bin design and refrigeration airflow

There are several methods to achieve airflow between the bins, including the design of the bins themselves but also in terms of the depth of the stacking. Limiting the bins to a maximum of three or four deep to the side walls and leaving gaps between stacks is a useful rule of thumb to mitigate poorly distributed refrigeration airflow and also this has benefits regarding stocking and retrieval access. Bins can also have “legs” and interlocking stacking feet which also benefit the refrigeration of the stock by creating a gap between stacked bins. Some bins simply stack directly onto each other, closing this gap, and these should be avoided.

Figure 11. Tuna bins at -40°C, Japan.

Isles and door dimensions

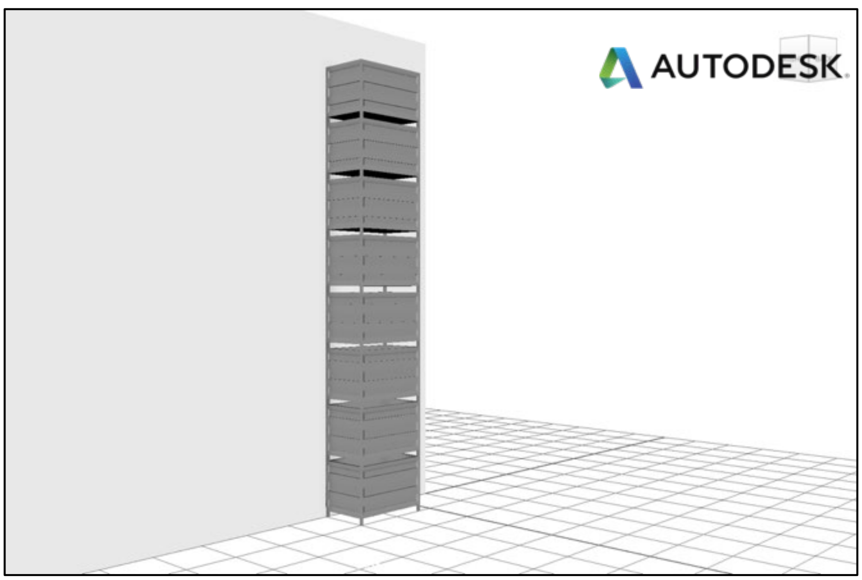
The door width should be around 2m to 3m, however, this will also depend on the size of forklift procured. A smaller footprint forklift with an adequate lifting capacity is a critical investment to reduce the size of the void space, and, obviously, narrower bins orientated on the forks result in less need for a wider door. The size of the door opening is a factor which is critical in terms of mitigating thermal transfer, gaining thermal energy in the cold storeroom, during logistical operations. However, besides the width of the bins, the bins and forklift must be able to pass through and under the door while the forklift reach should be, for example over 7m, if the bins are to be stacked 8 high. The isle width should also be able to accommodate adequate turning space for the forklift while loaded.

Estimating capacity and size of the cold storeroom

The following calculations and figures (CAD renders) are designed as visualisation to assist future detailed planning of the cold store. They also lead the reader through the rationale for the bin identified for the tuna cold store and why other kinds of bin are not suitable, which enables the dimensions of the suggested cold rooms on the Marshall Islands to be defined.

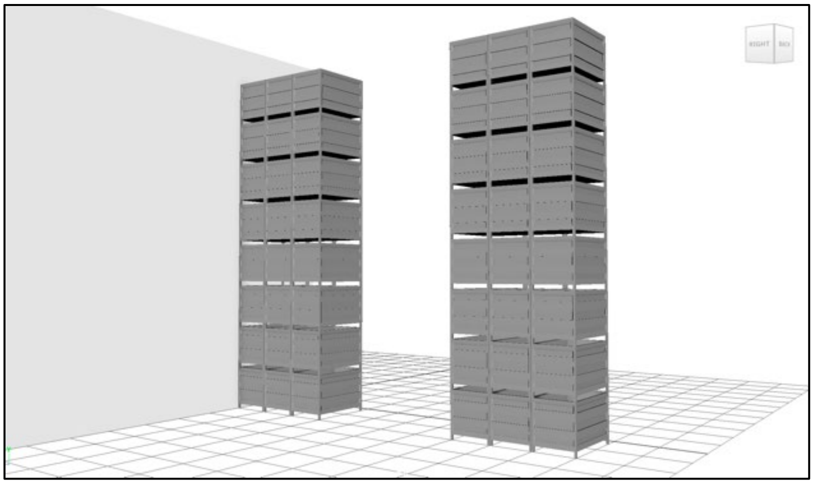
Using the parameters, the bin stacking height, bin stack depth, and isle width, the total ceiling height and total width of the cold store can be determined. From this, we can use a volume calculation of MT of fish per bin to estimate the capacity of the cold storeroom. Cold store tuna bins are typically just under two meters long (typically in the region of 170cm or less), one meter wide and just over one meter tall including the legs, stacking pins or flanges, depending upon the design. The estimate of MT of tuna per bin should be kept conservative at around 0.3MT per m3 as fish cannot be piled mounded due to the need for stacking. This can be compared to a 40ft container which, at nearly 60m3 holds between 20 and 26MT of tuna, resulting in the same conservative calculation of 0.3MT/m3.

Figure 12. Eight bins stacked lengthways against the long wall of a cold room, parallel to the isle store 4mt of tuna



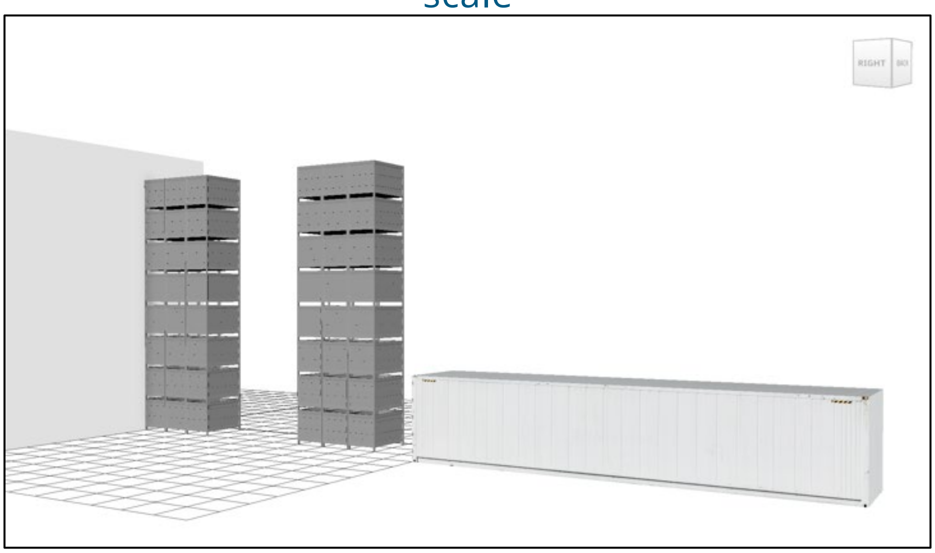
So, the calculation for bin capacity is therefore approximately 1.7m x 1m x 1m multiplied by 0.3MT/m3 which equates to around 0.51Mt per bin. This also provides a useful output for specifications for the forklift required however, obviously, the mass of the bin should be added to calculate the total load.

Figure 13. A "slice" of efficient stacking of 48 tuna bins in a cold storeroom



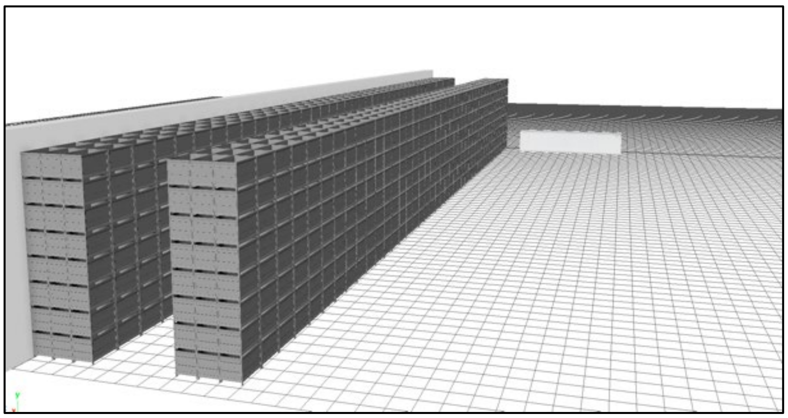
If we use this calculation, we can estimate that one bin length “slice” of cold store (over 1.7m in length), with bins orientated length ways along the length of the wall, as required for lifting, three stacks deep each side of the isle, and eight bins high, totaling 3 x 8 x 2 bins, or 48 bins, has a capacity of 48 bins x 0.5Mt of tuna, a total of 24Mt. This equates to about the same capacity of a container.

Figure 14. 48 tuna bins in comparison to one 40ft reefer container to scale



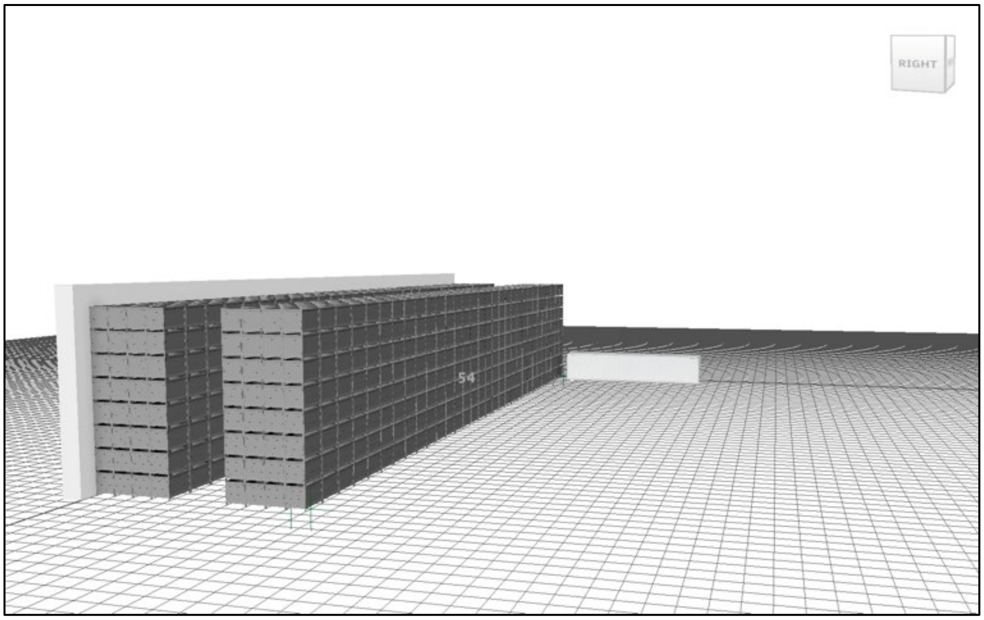
In this way, it is easy to visualise the capacity of the store per stacked bin “slice”. With this calculation we can estimate that to accommodate a capacity of 1000MT using the following calculation; (1000MT / 24MT) x 1.7m = 70.83m. Accounting for gaps between bins stacks, which are necessary for air circulation and logistics, we can estimate that this length should be around 72m long to have capacity for the 2000 bins necessary to accommodate the 1000MT of tuna and around 12m wide to accommodate three stacks either side of the isle and 10m high to accommodate the stacked bins.

Figure 15. CAD render of 1000MT of tuna bins and a 40ft reefer container to scale



If we rerun these calculations for four stacks deep as in photograph above, the resulting cold storeroom is around 14m wide, 55m long and 10m high to accommodate 1000MT of tuna in 2000 bins. We can then state that also, for 1 000Mt of tuna, around 750m2 of footprint is required.

Figure 16. CAD render of a 750m2 cold store for 1000MT of tuna



However, estimates of tuna bin capacity vary depending upon the stock ranging from 0.3MT/m3 to 0.5MT/m3 and in the case of the Marshall Islands, it is recommended that collapsible modular bins are used to enable variations in cold room store use. Combinations of steel bins, palettes, plastic bins and steel racks and hangers can also be used when necessary and folding bins which can be stowed flat enable cold room space to be repurposed.

Figure 17. Tuna stored on steel racks.

The limitation to these modular bins is that the recommended stacking height is 6 units high. However, there benefits to these bins as they are deeper measuring 160cm x 125cm x 96cm and can store in the region of 0.8Mt to 1Mt of tuna. Additionally, they are narrower (than 170cm) and narrow bins result in a narrower door width and the limited stacking height results in a smaller forklift, and so also door height. Based on a calculation of 1Mt per bin, 24 bins are comparable to a container and stacking bins 6 units high and 4 deep, with a 3.75m isle, including spacing between stacked bins, the resulting internal dimensions of a 1000MT cold room is 37m x 14m, 518m2.

Figure 18. CAD render of modular folding bins stacked 7 high in comparison to a 40ft reefer container.

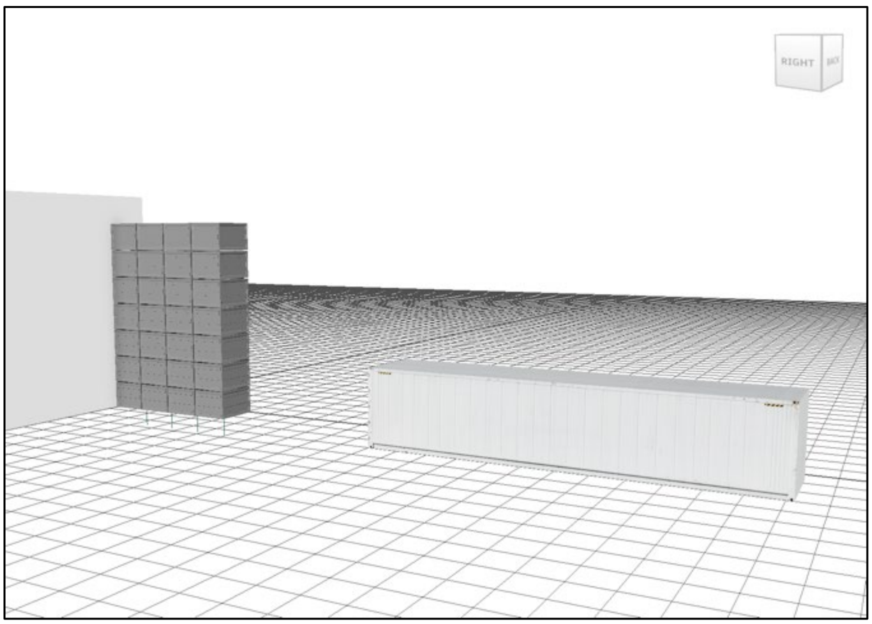


Figure 19. CAD render view of 1000Mt of volume of modular folding tuna bins stacked inside the cold room

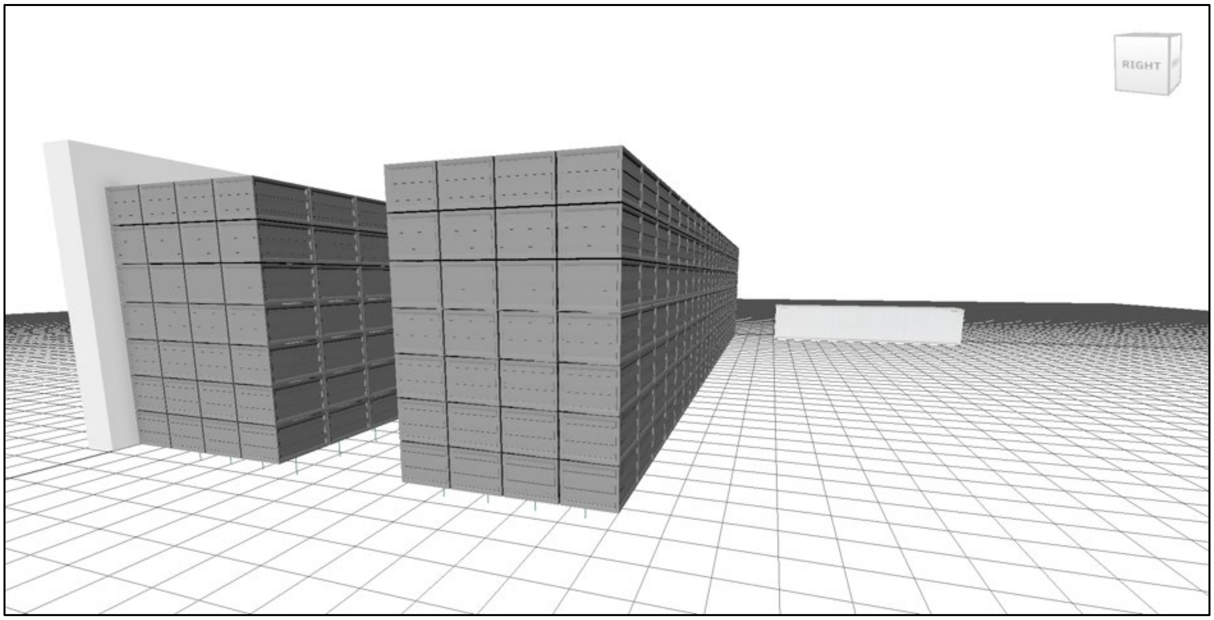


Figure 20. CAD render view of 1000Mt of volume of modular folding tuna bins stacked inside the cold room.

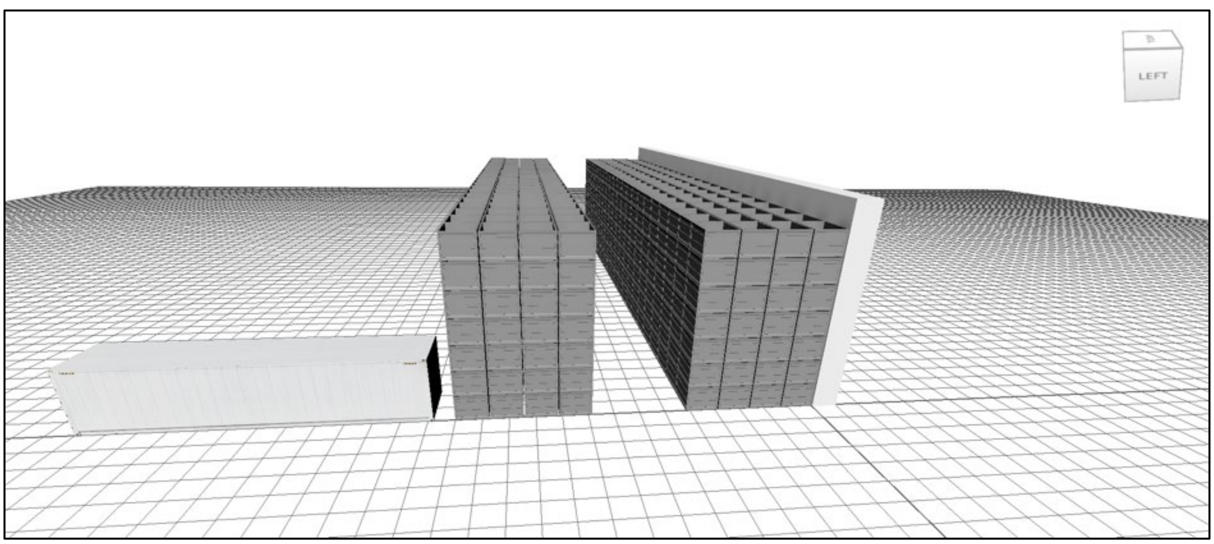
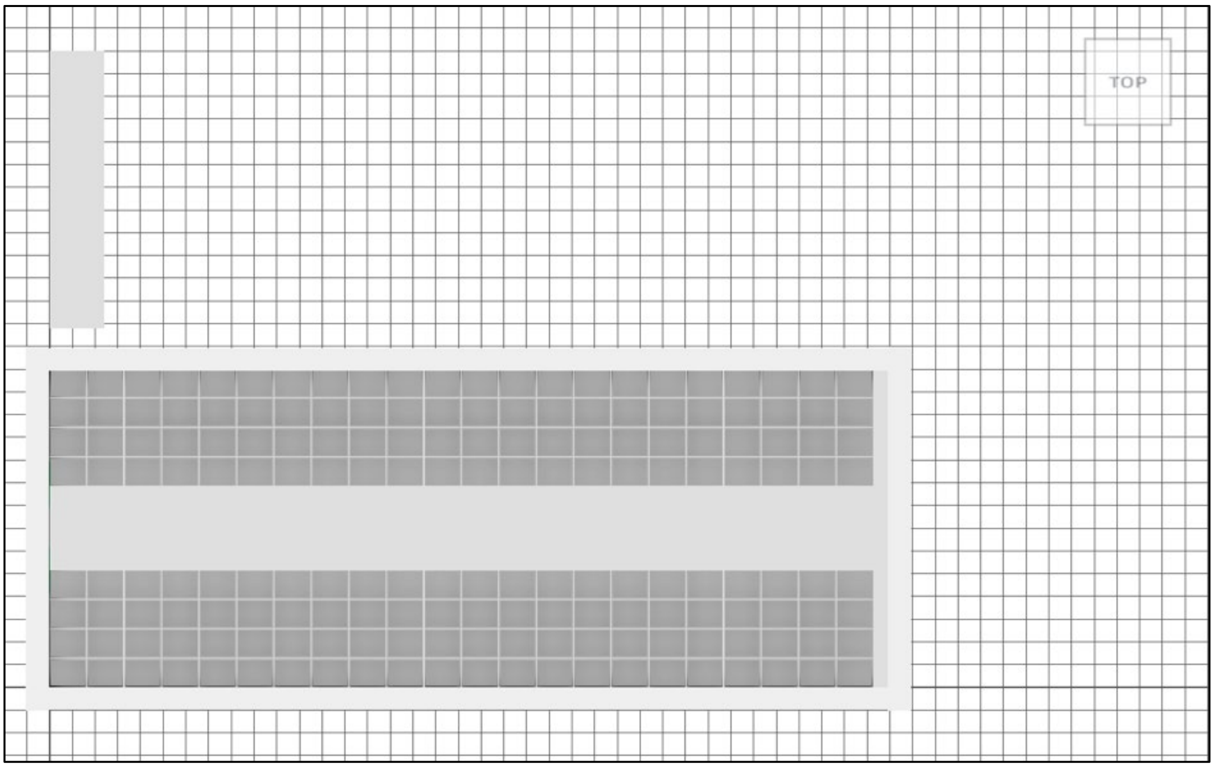


Figure 21. Orthographic top view of the 14m x 37m x 8m cold store and a container (top left) for comparison.



Key takeaways - estimating capacity and size of the cold storeroom

To summarise, a cold storeroom for 1 000Mt of tuna.

- Requires approximately 2000 bins.
- A forklift with a lift height of over 7m capable of lifting 0.5Mt of tuna plus the mass of the bin.
- Has a footprint in the region of 750m2.

Cost Considerations - estimating capacity and size of the cold storeroom

- Bins cost in the upwards of USD 500 with specific shipping considerations due to volumes required. For one 1 000Mt cold room, this equates to approximately USD1million USD.
- Bins can be procured in folding form, which reduces shipping and handling fees, and also enables a level of flexibility for storage when not in use, however overall costs are similar.

If careful scrutiny is applied to satellite imagery of cold stores, it can be rapidly deduced that very frequently, storage capacity claimed is overstated so it is important to be diligent when comparing tuna cold stores in terms of characteristics such as infrastructure requirements, economics and volume.

Structural considerations for stacking bins

It is both structurally and logistically difficult to stack more than 8 bins high of tuna. This is due to the mass of the bins and also the cost effectiveness of the type of bins which are needed to stack any higher. An additional critical consideration which is that the cold store floor needs to have specific grade concrete, and insulation material, in order to withstand the pressures, wear and tear, temperature changes, and chemical deterioration due to, for example, ingression of ammonia salts over time.

A calculation can be made regarding the weight of the bins and the static overhead pressure on the floor of the cold store.

- Using the conservative estimate of 0.5 Mt per bin, we can state that a stack of 8 bins high results in a vertical load of over 4 Mt.

- If the bins stand on cornered feet and/or rims (so can be stacked) which are significantly less surface area than the entire container. We can calculate this contact area as a best-case estimate to be that perimeter of the base of the bin with a best-case assumption that it is around 2cm wide (worst case for air circulation). This results in a calculation of about 0.108m2 of contact with the floor per bin. From this we can calculate the approximate contact pressure (dead weight calculation) of the lowest bin on the cold room floor as around 408.750KPa, or in the region of 59psi.

- However, if the contact of the lowest bin is only standing on the floor on feet, worst case for pressure on the floor but best case for air circulation, for example, 5cmx10cm (x4 feet) the area is 0.02m2 resulting in a pressure under each foot of 2207.250KPa or in the region of 320psi.

From this example, it is clear that it is essential for the floor of the cold store to be constructed from adequate grade floor insulation panels and concrete, particularly as these calculations are not considering the loading of the 8th (top) steel bin on top of the 7 bins below during forklift operations.

Key takeaways - structural considerations for stacking bins

The main outcome of this calculation, besides the quality of the ferrocement needed, is that the minimum requirements for the insulation panels for the floor should be at triple stacked extruded polystyrene (XPS) 3500KPA compressive strength typically resulting in a U value is 0.029 W/m*K.

Cost considerations

Floor insulation, including barriers, can be calculated at around USD 17 per m2, which can be calculated conservatively at around 10 000 USD per 1000MT cold room, in the region of 30 000 USD in total for a 3 000 Mt cold store facility or 1 000 USD for a 1 000 Mt volume.

Mitigating frost heaving

This section makes some of the most critical recommendations relating to the floor of the cold store specifically in the case of a cold store on the Marshall Islands. This is due to a number of factors which are, the ambient wet bulb temperature of around 28 to 30°C, humidity of around 85% and the hydrology of the site location at Kramer Dock which is affected by changes in sea level and tidal cycles. From this section, we can also understand why reclaimed land is less favourable for the location of a cold store to both operate efficiently, with less operational costs, and mitigate depreciation of a critical structure, the cold room floor. A critical concept which we need to understand is that solids and liquids typically conduct heat far better than gasses. To summarise (higher value = better conductivity).

Thermal conductivity of concrete = ~2.25 $W\ m^{-1}\ K^{-1}$
Thermal conductivity of water = 0.598 $W\ m^{-1}\ K^{-1}$
Thermal conductivity of air = $0.0026 - 0.0068 \times 10^{-2}\ W\ m^{-1}\ K^{-1}$

When the temperature of saturated sub-grade soil or aggregate in contact with the concrete floors of a cold store area dips below 0°C, this causes pockets of moisture within the aggregate to freeze, this is called frost heaving. The reason for this is that heat is being removed from the storage area's concrete floor and continues to remove heat past the floor's protective insulation. Warm moist air in the soil or aggregate naturally moves toward the cooler, lower pressure air inside the storage room until the two reach an equilibrium. Once the aggregate freezes it forms ice lenses that push upward with enormous pressure, "heaving" the concrete above, lifting columns, and distorting the building's foundation. If left unchecked, severe frost heave can result in an entire building being condemned and demolished.

Figure 22. Diagram of how an ice lens "heaves" the floor of the cold room if directly laid on top of the ground with no floor heating or other frost heaving mitigation strategy.

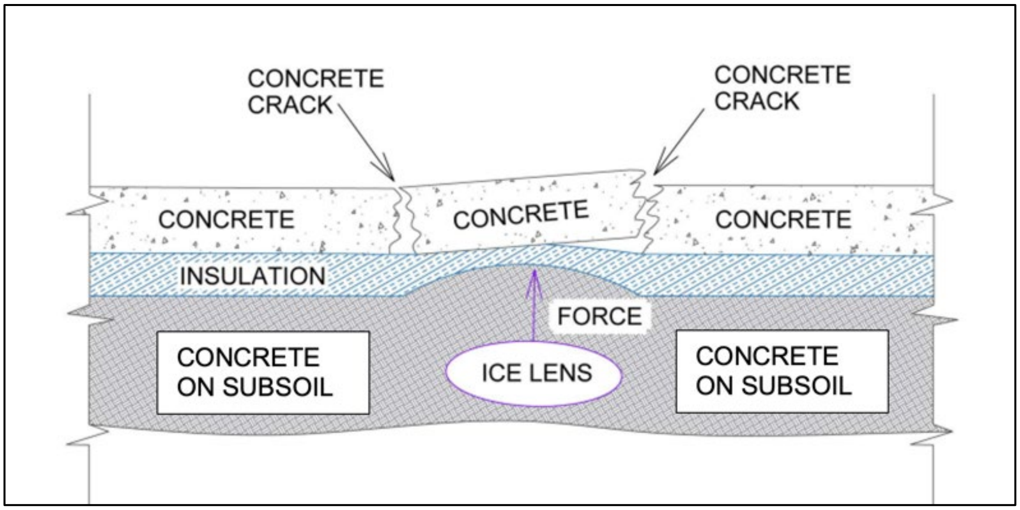


Figure 23. Frost heaving on a cold room floor

Frost heave develops slowly initially with a small cracks and bulges in the concrete. The floor grade becoming uneven, leading to disrupted pallets, tilted racks, and problems manoeuvring forklifts. Doors may also no longer close as originally designed and the room's corners also may appear to be sinking. Without repair, this will continue until the structural integrity of the building is severely compromised, and any repairs both make the room inoperable and also result in a room which differs from the original thermal characteristics which the business model was intended.

Key Takeaways - mitigating frost heaving

- Note that this is the area and not limited to directly below the cold room and can "travel" in a wider area, particularly if low temperatures, such as those for tuna storage, are required by the cold store.
- High or variable water tables and high humidity accelerate this process. Even if this is saline water, or sea water of 35 parts per thousand (or 3.5%) will have a freezing point of around -1.8° C and does not mitigate frost heaving when cold stores are operating at low temperatures.
- Most importantly, these conditions occur when the cold store area floor is in contact with the soil or aggregate.

How can frost heaving be prevented in the case of a cold store on the Marshall Islands?

Underfloor heating systems are typically installed to mitigate frost heaving. The amount of heat required is dependent on the slab surface temperature, how much insulation has been installed, the thermal properties of the soil, and the volume of moisture within it. However, this is a costly process and typically prohibits use in large areas. It also adds another potential risk should it fail and in the case of the Marshall Islands, reducing critical operational risk is a critical consideration. Another intervention to prevent frost heaving is by integrating poly vapor barriers and slip-sheet.

However, for the Marshall Islands, due to the size of the tuna cold store, the low temperatures required, the projected modular implementation, and the ambient temperature and humidity, another solution is preferable. This is to create a void space beneath the main cold store and controlled environment areas where natural ventilation allows air flowing freely across the underside of the concrete floor below the insulation. Having no operational energy costs this is a far more suitable option for RMI where there is high ambient temperature, and air movement from wind. However, this void must be above ground level and requires careful construction planning in order for the cold room to have adequate structural support. This should be in combination with a forced air ventilation pipe system integrated into the floor, which will be elaborated on in the following insulation section.

Key takeaways – case specific frost heaving mitigation

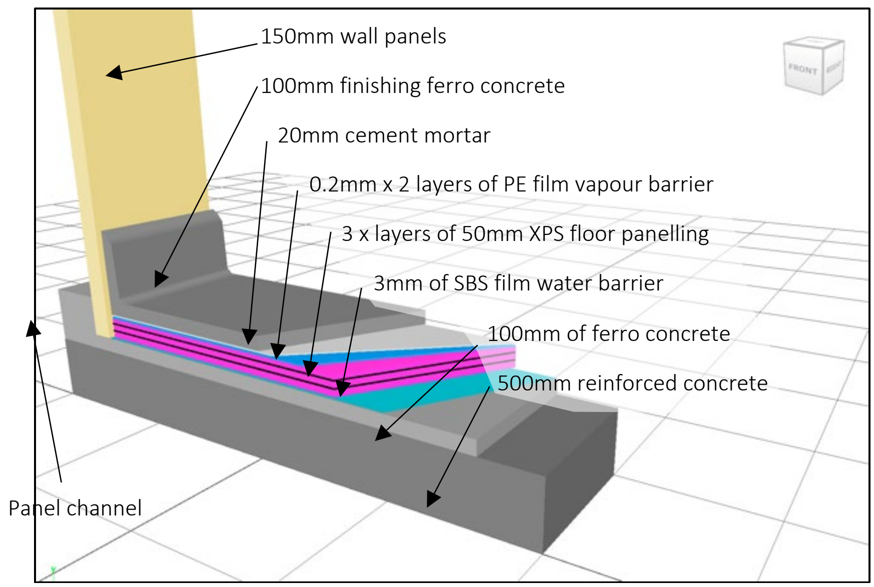
- Creating a void space is a critical recommendation for the construction of a cold store on RMI to both reduce operational cost and risk and ensure the sustainability of the entire structure.
- From thermal analysis in past case studies, this should create a space, minimum height of 1.4m above the foundations.

Insulation paneling

The following information is recommendations for construction of the insulation wall panels and flooring.

Extruded polystyrene (XPS) insulation panelling should be rated with a PIR density: 42±2 kg/m3, and a fire rating of B1 (flame retardant). The panels should be 150mm thick with baosteel or similar high quality 0.5mm plate on both sides.

Figure 24. Diagram of the layup of the cold room floor



For the floor, two layers of polyethylene (PE) 0.2mm vapour barrier should be laid under 20mm of cement mortar with an upper layer of ferrocement for the floor 100mm thick curbing (minimum) up to the panels to around 40cm. Below this three layers of 50mm XPS floor panels with 350KPA compressive strength, a U value of 0.029 W/m*K and should be laid on a 3mm Poly(Styrene Butadiene Styrene – SBS) water barrier film a top of a further layer of 100mm of ferrocement.

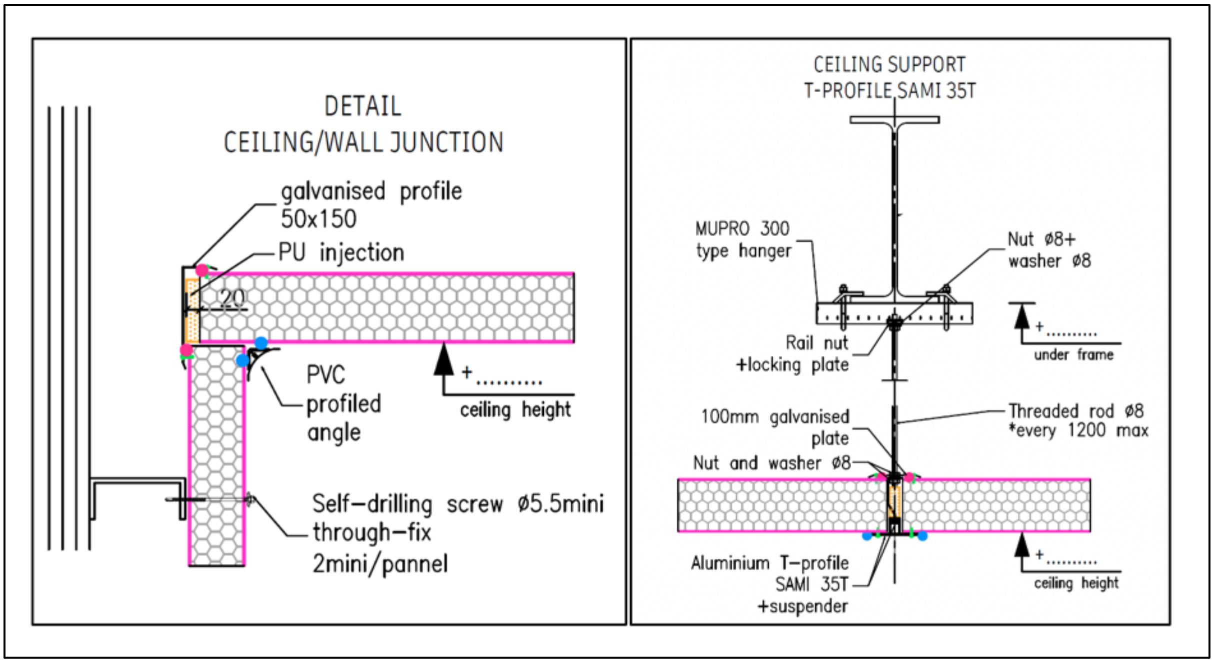
All films and barriers should overlap no less than 500mm. Additional curbs can be added to mitigate damage to integrated curbs in order to mitigate damage from manoeuvring bins. However, thicker curbing comes at a cost to the overall volume of the cold room volume.

Figure 25. Cold room panel installation, China

Source: Michael Chen

The following detail diagrams are designed to support the drafting of comprehensive plans and technical specifications. For wall panelling, all rivets to hangers should be capped or sunk to minimise thermal conduction and ideally fixed to structural walls/supports every 500mm. Polyurethane grouting injection (PU injection) should be used at all corners and joints. The following plans are not exhaustive however fulfil the scope of this document in order to approximately quantify required amounts of materials and calculate an estimate of costs. This calculation includes all items such as main suspension for roof panels (including aluminium channel, steel cables, screws), assistant hangers for roof panels (including mushroom heads, screws, steel cables), ring beams for wall panels (including C steel channel, mushroom heads, fasteners, etc.) U shape steel profile for wall panels, L shape steel profile, for wall and roof panels, L shape aluminium profile, for wall panels, balance windows (pressure release valves), all silicone sealants, all components for electric doors (2.2m x 3.5m), expandable spray foam, PU foam, rivets, fasteners and other required steel profiles.

Figure 26. CAD draft detail of cold room insulation fittings and fixtures



Cost considerations - insulation paneling

For three cold storerooms, total capacity for 3 000 Mt of tuna, with inner dimensions of 37m x 14m x 8m, the total costs for insulation and fittings are estimated to be in the region of 80 000 USD per room totaling 240 000 USD.

Refrigeration gas

There are key benefits as to why ammonia could be selected as the refrigerant to be used in this feasibility study, and this choice is due to four major advantages over CFCs and HCFCs. These advantages relate to build, operational and environmental costs and that an ammonia-based refrigeration system can cost 10-20 percent less to build than one that uses CFCs because narrower-diameter piping can be used. Ammonia is also 3-10 percent more efficient refrigerant than CFCs, so an ammonia-based system requires less electricity and so results in lower operating costs. Additionally, it is a substantially less expensive refrigerant than CFCs or HCFCs. Lastly Ammonia has an Ozone Depletion Potential (ODP) rating of 0 and a Global Warming Potential (GWP) rating of 0.

However, there are some disadvantages to using ammonia as a refrigerant in that it is not compatible with copper, and so cannot be used in a system with copper pipes, and it is also poisonous in high concentrations. However, countering this risk is that ammonia has a very distinctive smell and is detectable at concentrations well below those which are considered dangerous. Additionally, ammonia is lighter than air and so leaks will rise and dissipate in the atmosphere. However, another choice of gas may be chosen due to these factors.

Safety considerations for refrigerant

Due to the location of the proposed site, no machine room fans would blow and discharged ammonia onto a highly populated area. This accounts for the unlikely scenario where, should there be a refrigerant leak, the gas will not interact with any residential area. Additionally, due to the exposed nature of the location, and wind conditions, any discharge would also very rapidly dissipate. This also mitigates the need for any ammonia air scrubber installation at the cold store facility. However, fans, and ducting, typically meeting specifications similar to ATEX/IECEx explosion proof certification should be fitted to the machine room/plant to ensure that, should there be a refrigerant leak, adequate ventilation can ventilate the area and move any gas out of the enclosed space. These have an estimated cost of around 2 000 to 4 000 USD per unit and as an estimate, a minimum of six units rated at 4 000m3/h should be used.

Cost considerations – safety considerations for refrigerant

ATEX/IECEx rated fans and installation costs including switching may cost in the region of USD 30 000 including shipping.

Initial cooling load calculations

The following conservative calculations provide cooling load calculations for maximum capacity and minimum logistical changes.

- For one cold room unit of 1 000Mt capacity of tuna internally measuring 37m x 14m, an 8m high ceiling.
- Total floor area of 518m2 and total walls and ceiling panel area 1134m2.
- Wall panels rated at U = 0.14W/m² K, and floor panel U value of 0.029/m² K.
- External temperature is estimated at of 30°C, internal temperature of -20°C.
- The specific Heat Capacity of Tuna 0.8 kcal/kg C or 1.6 kJ/kg K
- Evaporator fans rated at 6400W (aggregated) with an operational time of 14 hours.
- Evaporator defrosting at 4 cycles of 0.5 hours per day at 68kw, estimated efficiency at 30%.
- Product Respiration is considered not applicable.

<u>Transmission load</u>

Transmission Load - Walls and Ceiling
Q = 0.14 x 1334 x 50 x 24 ÷ 1000 = 224.112 kWh/day

Transmission Load - Floor
Q = 0.029 x 518 x 50 x 24 ÷ 1000 = 18 kWh/day

Total transmission load = 242kWh/day

<u>Equipment load</u>

Equipment Load - Evaporators
Q = 1 x 14 x 6400 / 1000 = 89.6kWh/day

Equipment Load - Defrosting
Q = 68 x 0.5 x 4 x 0.3 = 40.8kWh/day

Total equipment load = 130.4kWh/day

Total transmission loads and equipment loads = 372.4kWh/day

<u>Products load</u>

Products load at static maximum capacity (no tuna is logistically moved)
Specific Heat Capacity of Tuna 0.8 kcal/kg C or 1.6 kJ/kg K
Q = 1000000 x 1.6 x (2) / 3600 = 888.888 kWh/day

<u>Internal heat load</u>

Internal Heat Load (at 2 people and 1 hour)
Q = 2 x 1 x 270 ÷ 1000 = 0.54 kWh/day
Internal Heat Load Lighting

30 lamps at 100w each total 1 hour
Q = 30 x 1 x 100 ÷ 1000 = 3kWh/day
Total internal heat load = 3.54kWh/day

Infiltration load
The estimated volume of air exchange from the door opening is calculated very conservatively, considering the logistical scenario as being half the total volume of the cold room at 2072m3, each cubic meter of new air providing 2kJ/°C. Q = 1 x 2072m3 x 2kJ/°C x (48) / 3600 = 57.5 kWh/day

Total cooling load of all calculations = 1695kWh/day required for 14 hours operating time of one 1000MT cold storeroom
Contingency Factor of 10% = 1864.5kWh/day
Contingency Factor of 30% = 2203.5kWh/day

Refrigeration cooling capacity required for 14 hours operating time of one 1000MT cold storeroom.
At 10% safety factor = 133.2kW
At 30% safety factor = 157.4kW

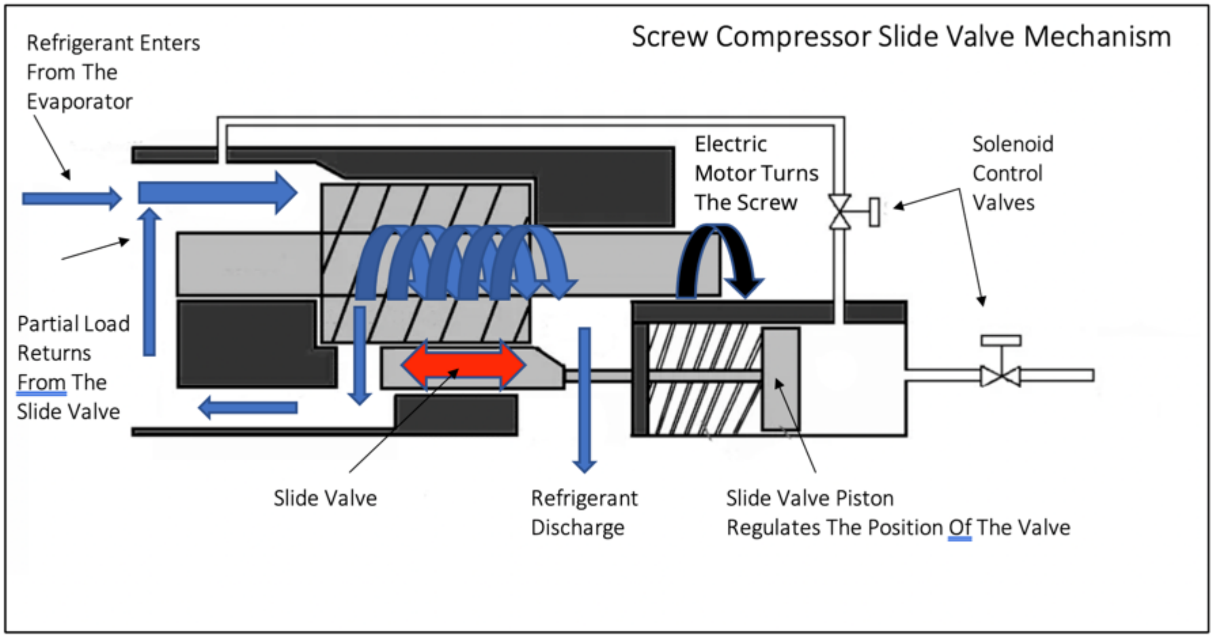
Compressors

As can be seen from the previous cooling load calculations, one of the highest operating costs of a cold store facility is often mechanically removing heat from cold rooms. In the case of RMI, keeping this cost to a minimum is a key objective for feasibility to be achieved and all design considerations need to be constantly checked against this priority.

To achieve an economy of scale, multiple compressors should be used to remove heat from the cold room. The advantage of the scenario in RMI, compared to many other locations, is that annual ambient temperatures vary very little, and the load considerations are far more constant, than, for example, cold stores in temperate conditions. As a result of these factors, calculating maximum potential for load is in many ways more straightforward as the ambient thermal variance is relatively minimal. Additionally, much of the stock to be loaded into the cold store is pre frozen, which also reduces variance in considering power consumption for the system. By using a staged and redundant system which uses three screw compressors, it is possible to create a system for RMI which scales output for lesser load (power consumption).

There are also some efficiency considerations in terms of the compressor loading and unloading which should also be considered and are often overlooked. Screw compressors have three main states of operation, loaded, unloaded, and stopped and often in lower cost installations operate by limiting the flow of compression through a device called a slide valve. When fully unloaded, no gas moves through the system. The method recommended to improve efficiency is to add an inverter drive to a screw compressor which can save as much as 30 percent of the absorbed power. This is because the compressor can operate with the slide valve fully open as the compressor can run using variable speed rather than moderating the valve. Using the slide valve to produce part load conditions results in inefficiency due to fluid dynamic effects because the screw compressor is designed to have maximum performance with 100 percent slide valve load. So, adding an inverter to the system, mitigating the slide valve being partially closed, enables the rotor to run at a more optimum condition by regulating the speed of the rotor, rather than, what could be thought of, as throttling the load with the slide valve.

Figure 27. Detail diagram of the slider valve mechanism



In the diagram, it can be seen that when the slide valve is fully unloaded, moving to the right, no gas is discharged and returns into the suction intake. When the valve is in the position, as in the diagram above, partially closed, some of the gas returns to the suction intake and some is discharged. This method to regulate load, is inefficient and using an inverter to regulate the speed of the motor turning the screw, is much more efficient.

Another benefit of using an inverter to regulate the speed is that the machine is frequently under load conditions which result in less wear and tear on depreciating components such as drive coupling inserts and inlet valve seals. Although modifying screw compressors to run at variable speed is possible, they tend to only be capable of varying speed down to around 50% of the speed of the maximum design capacity. However, investing in purpose built variable speed drive compressors with inverters can be a worthwhile investment as they can run motors as slow as 20% of the maximum speed/compressor capacity. Both these characteristics result in lower maintenance and depreciation which, overall, is another key benefit of screw compressors. Other benefits are that screw compressors also reduce refrigerant loss, have less vibration, more simplistic maintenance routines and have high output per kW of electrical energy used.

From cooling load calculations, three compressors are recommended for the RMI cold store and should be in the region of 140kW. Mycom/Mayekawa or Bitzer would be recommended choice due to reliability, and access to spare parts. This is reflected in situ on RMI as the existing flaked ice production in Majuro has successfully run with a Mycom compressor for approximately 10 years. When choosing electric motors, these should also be selected on the basis of reliability and rapid access to spares which can be flown to RMI and ease of maintenance. Regarding operating voltage, typically support for three phase 400/380v 50/60Hz infrastructure is more accessible than higher voltage 150Hz systems and is therefore also recommended.

Control systems ideally should integrate Danfoss solenoid's, expansion valves, pressure control systems and data management systems as these have clear benefits in terms of monitoring temperature control which relates directly to adding value and certification. Other electrical control systems should ideally be manufactured by Schneider Electric or similar brands which have reliable global supply chains and component quality control with a high reputation for reliability, efficiency, and sustainability as a primary concern. Any control systems should be housed in conditions which prevent corrosion, ideally a protected control room environment situated inside the machine room. Additionally, having the three compressors, as is recommended, results in a system with a level of redundancy where two compressors can operate, and one can be on standby or under maintenance.

Key takeaways - compressors

- Although they have a high initial cost and are often overlooked for this reason, screw compressors have a broad range of benefits, particularly in terms of depreciation and maintenance.
- Using a purpose-built variable speed compressor can improve operational costs by up to 30%.

Cost Considerations

For three variable speed screw compressors and associated valves and control systems, the estimated cost, including shipping is in the region of USD 160 000 for three 1 000 Mt cold rooms (i.e. capacity for scale-up).

Condensers, evaporators and associated pipework

Although various options for condensers were scoped, in order to keep implementation and operational costs down, air cooled condensers are recommended. This study examined the technical feasibility of deep ocean water cooling, integrated with an ethylene glycol solution circulating back to the condensers. However, the main factor prohibiting this is that in order to gain any efficiency in terms of reaching cooler sea water, pipework would most likely need to descend in excess of 300m and the cost of pumping the seawater would be inefficient unless some method of renewable pumping was used such as a wind turbine. Although feasible theoretically, this solution would also have reliability issues as, although wind is extremely regular, there are times of the day when the system may not be able to meet the cooling capacity. This approach would also require a more in-depth environmental assessment and possibly result in considerable civil engineering costs.

The air-cooled condensers for the cold room should, per unit, have a capacity of around 140 kW, with four fans rated at around 1kW each and a heat exchange area of round 500m2. With a total of six units required, the estimated cost per unit being somewhere between 5000 USD and 10 000 USD, bringing the total cost, as a high estimate to be 60 000 USD.

Six evaporators each with a nominal capacity of around 60kW and heat exchange area of around 300m2 should provide adequate airflow at around 50,000m3/h and each evaporator fan is estimated to use around 3.2kW of electrical power. The estimated cost per unit being somewhere between 4 000 USD and 8 000 USD, bringing the total cost, as a high estimate to be 56 000 USD.

Both evaporators and condensers should be contained in at least 304 rated stainless-steel housings and all pipework should have additional barrier coatings/paints applied.

Cost considerations - condensers, evaporators and associated pipework

Including pipework, additional coatings for pipework, evaporators and condensers, the total cost of these components, including shipping is estimated to be in the region of 150 000 USD for three 1 000 Mt cold rooms (i.e., capacity for scale up).

Power considerations

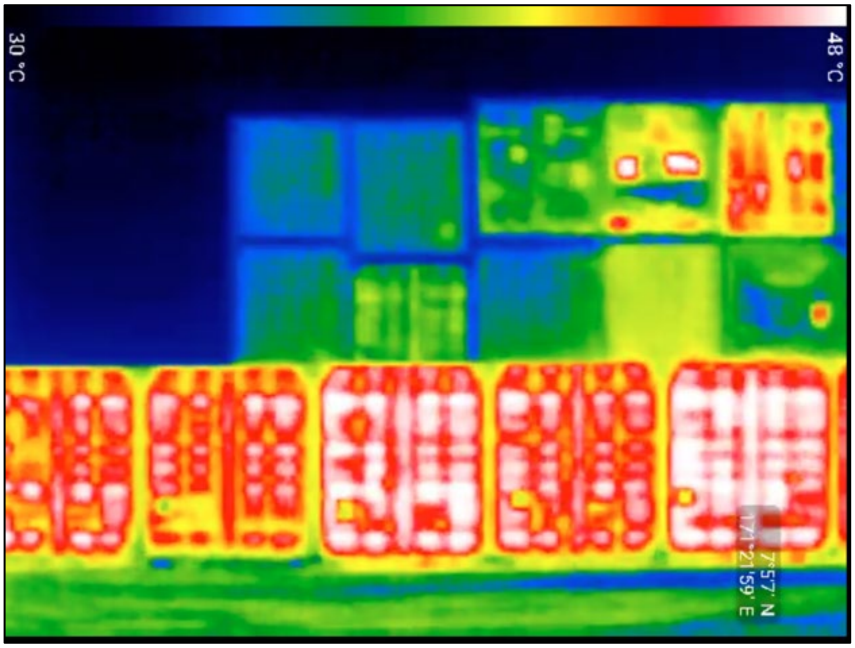
Based on the previous cooling calculations in this study, and assuming that the approximate cost of electricity on the Marshall Islands is around 0.35 USD per kWh from the local grid, the cost of running one 1000 Mt tuna cold storeroom at full capacity for 14 hours of operating per daytime are as follows.

Table 1. Cold storeroom cooling calculations for 1000Mt of tuna

1000MT Capacity Cold Storeroom Cooling Calculation For 1000MT Of Tuna	Total Daily Cost (USD)	Cost Day/MT (USD)	Cost per 24MT (USD) (e.g. ~ a container load)
1695kWh/day (upper estimate)	593.25	0.60	14.40
10% contingency 1864.5kWh/day	652.56	0.66	15.84
30% contingency 2203.5kWh/day	771.23	0.78	18.72
Cost of a day plug in rate for a container		3.13 to 3.54	75 to 85

The concept of an economy of scale concept is demonstrated in the data above through the comparison with a container as can the energy footprint. Although not accurately calculated in this study, reefer containers sun at around 8kW upwards at -18°C (not -20°C as calculated for the cold room) depending upon the load and the ambient temperature. This equates to over 192kWh per day, which, as a comparison works out as over 8 000kWh per day for 1 000MT of tuna, while the cold store runs at around a fifth of the power consumption and two degrees cooler in these estimates.

Figure 28. Thermal imagery (FLIR) of containers at Delap dock, December 2022.



Thermal image analysis of containers stacked at the Delap Dock, Majuro in December 2022. Refrigerated containers such as the one highlighted in the white square. Door ends of reefer containers are distinguishable as they are up to around 13°C (blue) cooler on the outside (inefficient) than unrefrigerated containers which can be seen at around 48°C (red and white). Using thermal cameras can also be a quick way low-cost way of assessing operational functionality of containers.

To provide another example model, at the opposite end of the scale, the cooling calculation of the 1 000Mt capacity cold room can be re-adjusted, including accounting for internal heat load and infiltration load (logistics) to represent a similar volume to 20 reefer containers, during storage and logistics.

Table 2. Cold storeroom cooling calculations for 240Mt of tuna

1000MT Capacity cold storeroom cooling calculation for 240MT Of Stored Tuna	Total daily cost (USD)	Cost per day/MT (USD)	Cost per 24MT (USD) (e.g. ~ a container load)
1020kWh/day (upper estimate)	357.00	1.49	43.78
10% contingency 1122kWh/day	392.70	1.64	48.17
30% contingency 1326kWh/day	464.10	1.93	56.92
Cost of a day plug in rate for a container		3.13 to 3.54	75 to 85

Between the two tables, the concept of economy of scale is yet again clearly demonstrated and the cold store only becomes very competitive against the container when it is at full capacity. To bring this competition even closer, the running cost, not the rental cost, of the container may be relatively calculated on the basis of $0.35/kWh as in the region of 67.20 USD per day (192Kwh x 0.32), around 10 USD more than the 30 percent contingency calculation of 240 Mt. Further cooling calculations imply that, on the basis of these values, refrigeration cost of the cold store room empty would be around 270 USD per day. The economy of scale characteristics from this analysis also assists in understanding modular and phased construction concepts as a large-scale investment is necessary from the outset in order for the cold store to be feasible and a threshold window can be estimated in terms of operational feasibility.

However, the previous power cost calculations are based on drawing from the utility grid in Majuro, and their 13.8KV supply requires further investment in transformer infrastructure in order to be used. Energy is lost in transformers is approximately 10 percent due to winding and core energy losses and needs to be built into this estimate. Redundancy should also be built into this investment and quality three phase oil cooled transformers can cost anywhere in the region of 20 000 USD per unit. There is also consideration for dependency on one power source alone, considering the value of the stock in the cold store, and this risk increases proportionally with the load on the electrical infrastructure. For this reason, investment in redundant generators and a microgrid with independent control systems and distribution is a vital investment for the facility.

From the cooling calculation, we know approximately what energy is required, however we do not know what generator will be used. As a conservative assumption, we will assume that the generator has a fuel map plot where efficiency is optimised at 80 percent of the maximum load and RPM. We can also determine that the kVA value for the generator to power one cold storeroom of 1 000 Mt needs to be as a conservative (upper) estimate, in the region of 188kVA based on the calculation for 2203.5kWh of consumption (1 000 Mt of tuna and 30 percent contingency), a power factor of 0.8 and an estimated operational time of 14 hours per day. Basing fuel consumption on the calorific value, to be around 0.2-0.25kg/kW.hour (one litre of diesel being 0.84-0.86 kg), a 200kVA generator will use 40 to 50 litres of fuel per hour, or 10 to 13 gallons per hour.

As an approximate estimate, if fuel is 2.20 USD/gallon the operational cost is 14 hours x 2.20 USD x 13 gallons, or 400.40 USD or 0.41 USD per Mt of tuna.

However, if the diesel used is 8 USD/gallon, the operational cost is 1 456 USD per day, or 1.46 USD per Mt or tuna.

At 8 USD a gallon, the operational cost is around 60 percent less than the rental of a container at 3.13 USD to 3.54 USD per Mt of tuna per day.

However, this figure does not account for depreciation or maintenance or power loss in the system, or other operational costs (forklift, utilities, water pumps, conveyors, plug in points for containers), and some costs should be adjusted by a minimum of 30 percent to account for depreciation alone along with the building over an estimated 20-year lifespan of the facility. While the Majuro grid may not be suitable for power for critical operations, it could be integrated as an optional source of power via microgrid control systems for single phase low voltage applications (e.g., lighting, office space, amenities).

Cost considerations – Power

It is advised that, as with the compressors, triple redundancy is built into any generator procurement and as an estimated cost, which will depend on the brand chosen, a total of 150 000 USD should be considered as a realistic value for generator investment.

Renewable energy sources

There are opportunities to further improve the efficiency of the cold store such as integrating renewables; however, these cost cutting methods all require an even greater initial investment, which, from a business plan perspective, raises the demand for a guaranteed client base. However, the use of renewables also reduce dependency on power generation through diesel generators which should be considered as a key environmental initiative in terms of investment.

Due to the size of the available space, the recommendation for renewable use is that a superior upper roof structure covers a large area of land where logistics of processing, sorting, grading, conveyors, containerization, plug-ins and the cold room, or rooms are located. Considering the previous thermal image of the containers, shade from solar energy would also make any containerization more efficient. At the time of the field visit, there was no opportunity to simulate a reefer container operating in the shade, however, it is estimated that running costs could be cut considerably, along with mitigating the risk of container failure and depreciation.

As an approximate estimate, around 600m2 of contemporary solar panels could host a 100kW solar array. However, solar calculations need to be scrutinised carefully. The energy efficiency of a solar cell is anywhere between 11 percent and with some more recent panels up to 20 percent efficient. This results in an estimate of approximately 14W to a best case 25W per m2. This equates to around 400kWh of AC power per day assuming that there are 5 hours of sun per day.

So, for example, if the proposed roof structure was 80m by 125m (1000m2) it could have the potential of providing around 540kWh per day. This has the potential to write off daytime operational costs considering the cold room.

There is also a method of storing this power which eliminates the need for a battery system. This is by dropping the temperature of the cold room in the daytime by using the solar power this results in the cold room acting like a form of battery and creates cost savings in the night. For the CCCS in the Seychelles, their roof solar cuts their daytime generated power load by up to 60 percent for 12 600Mt of tuna, with a total of 10 rooms of 1 000Mt, one being at -40°C. However, unlike the scenario at the Kramer Dock, they are more limited to land tenure per Mt of tuna, and the site at the Kramer dock has the potential to write off a considerable amount of daily power consumption for a smaller scale cold store, containerization and value adding facility.

Although wind power was considered, and may even be favourable over solar energy, costs of implementation were sought and deemed beyond the scope of investment for the project. This is due, in part, to the remoteness of the Marshall Islands.

Cost considerations - renewable energy sources

The total cost of solar arrays cost between 250 and 1 000 USD per m2 so a 1000m2 array could cost between 250 000 USD and 1 million USD. This depends upon the quality and number of panels procured, and associated cabling and inverters procured. This intervention could be scaled and upgraded over time.

Renewable battery storage

Another option, alongside dropping the daytime cold store temperature, would be to implement a battery container system into the microgrid. However, this, again increases investment costs. Due to fluctuations in battery market prices this is estimated at around 1000- USD/kW of battery storage. The battery infrastructure also needs to be able to meet the demands of the compressor, particularly in terms of start-up loading. Containerised options are available which are modular and scalable.

Cost considerations - renewable battery storage

A 500kWh containerised battery for specific integration in a solar microgrid costs in the region of 0.5 million USD.

Hybrid micro grid infrastructure

Any hybrid integration of generated and renewable power relies on an efficient, reliable micro grid management system with triple redundancy, particularly where loads from heavy industrial machinery such as screw compressors are concerned. Microgrid controllers are effectively the backbone of any hybrid operation and quality components and control systems have the potential to provide more efficient resilient and sustainable energy solutions. Manufacturers such as Schneider Electric lead in this field of control systems. Microgrid controller costs reported in the NREL database per megawatt range from 6 200 USD/MW to 470 000 USD/MW, with a mean of 155 000 USD/MW.

Cost considerations - hybrid micro grid infrastructure

An approximate estimate of microgrid controllers for one 1 000Mt cold store, integrated with generators and a solar array is upwards of 50 000 USD.

Figure 29. Internal and aerial views of the CCCS 12 600Mt cold store facility at Zone 14, Seychelles.

From the information gathered to far, it is possible to perceive a draft outline of an approximate design for a modular system which can have a level of phased implementation. The design concept identifies the key needs for implementation which ensure considerations for the feasibility of the cold store. This design is aimed at supporting the development of a more comprehensive layout and technical design specifications.

How can the cold store be feasible? And what are the key characteristics of cost benefits?
A fundamental consideration is that for a cold store on the Marshall Islands to be economically feasible, it cannot simply be considered alone as a competitive storage unit compared to containerization as this will not particularly incentivize growth and, from the cooling calculations, the margins are not competitive for small volumes.

The feasibility of the cold store depends upon; (and therefore cost benefits are)

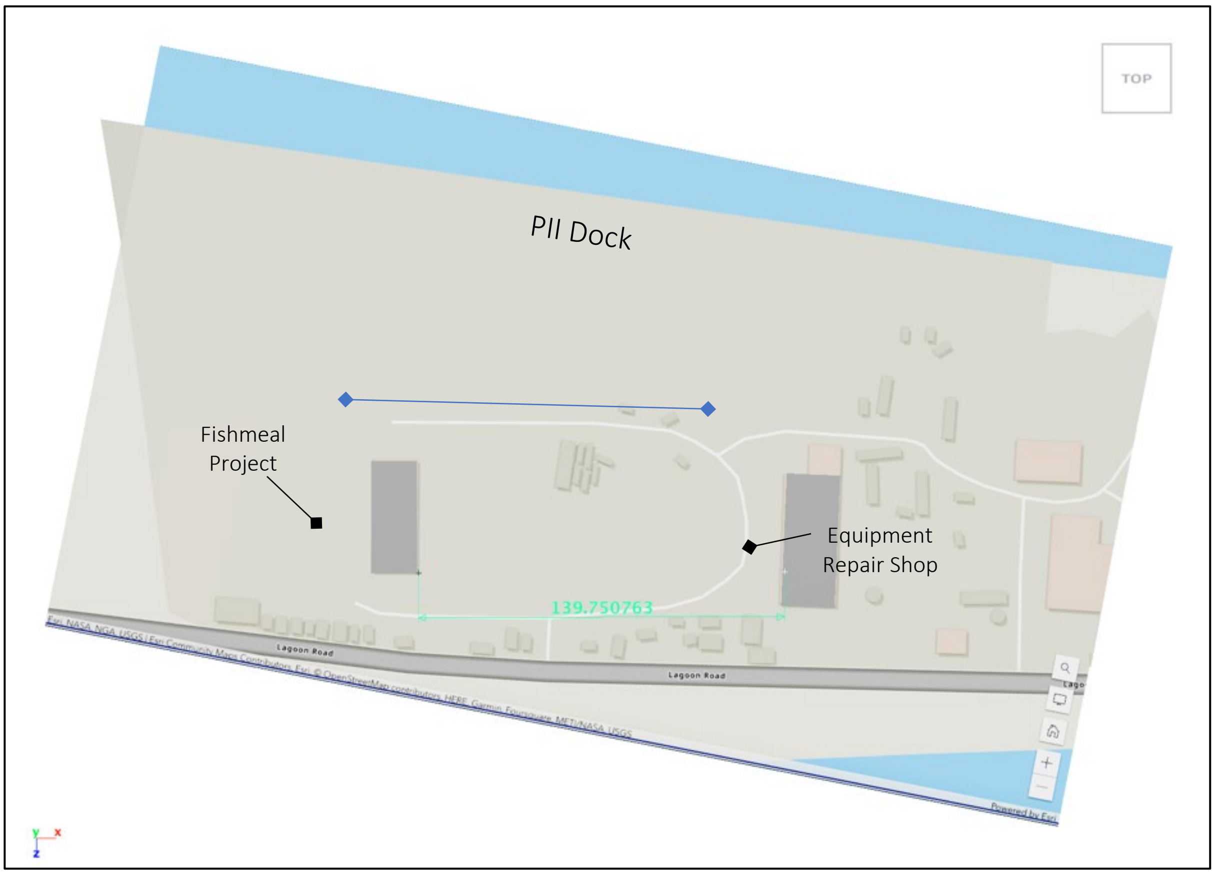
- Capacity for sorting, grading, and sizing in a controlled environment.
- A controlled environment which has the flexibility to meet any requirements of standards required for certification of commodities.
- The logistical capacity to manage and retrieve stock including efficient containerization via loading ports.
- Integration with a containerization plug in area in close vicinity.
- Considerations for investment in upgrading processing value chains in close vicinity.

The critical concept is that the cost benefits of investment in the cold store is that it offers opportunities for growth (i.e. increases landings of tuna) on the basis of an economy of scale, not only from a thermal perspective in terms of storage cost, and most critically, the cold store becomes financially viable through supporting opportunities for adding value by lowering operational costs and providing cost effective services to a high standard.

Implementation concept design

The following draft concept previsualisations are designed to stimulate discussion around the fundamental design characteristics which ensure the operational feasibility of the cold store. Considerations made in this design incorporate existing data and information from field surveys at the site and are approximately to scale using HERE, Garmin Foursquare, METI/NASA USGS data for scale referencing.

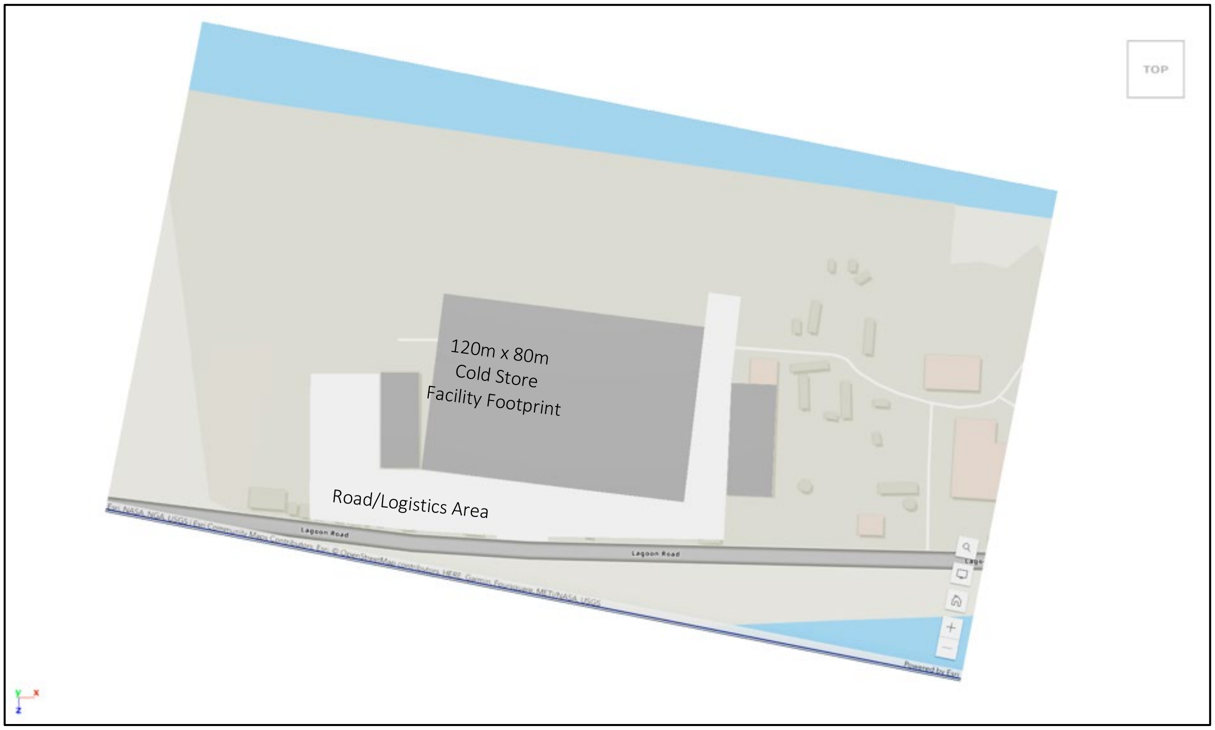
Figure 30. Map of the Kramer Dock, including projected dock extension infrastructure



Source: GIS data - ESRI Mapviewer

In the above map, the location defined between the fishmeal project and the equipment repair shop provides a site approximately 140m wide. This provides capacity for a footprint of 120m x 80m for the cold store facility area with 10m access either side. It is suggested that a new road and logistics area should be implemented at the site to access the dockside and the roadside of the facility efficiently.

Figure 31. Map of proposed cold store footprint and road at the Kramer Dock location



Source: GIS data - ESRI Mapviewer

The cold store facility is orientated to the new dock extension for logistical reasons to prioritise dock space, but also to orientate the facility so that the roof orientation maximises any solar installation implemented. The optimum orientation of PV panels at Majuro in this study is estimated at an azimuth of 180 degrees and a tilt of 7 degrees (GlobalSolarAtlas, 2023).

As advised in the section of this document addressing frost heaving issues, it is recommended that any cold storerooms are elevated by around 1.4m from the top of the foundation level. Thorough structural assessment should be undertaken in consideration of concrete loading of the cold room floor. This elevated floor level may seem to be a considerable investment; however, it has a number of key benefits besides to mitigate frost heaving. It also ensures considerations for flood risk which will be explored later in this document. Added to this, it assures the logistical height required for loading docks.

Figure 32. Orthographic cross section of the elevated cold room floor and air flow to mitigate frost heaving

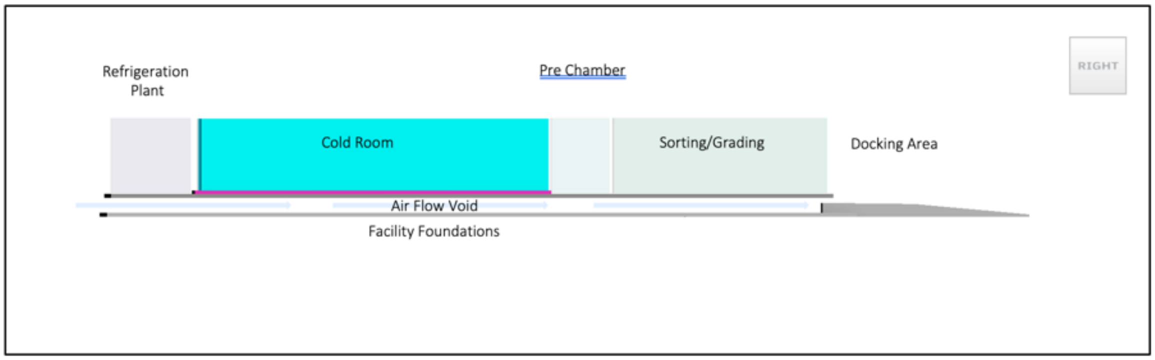


Figure 33. CAD rendering of the proposed cold store facility integrated with data from ESRI Mapviewer

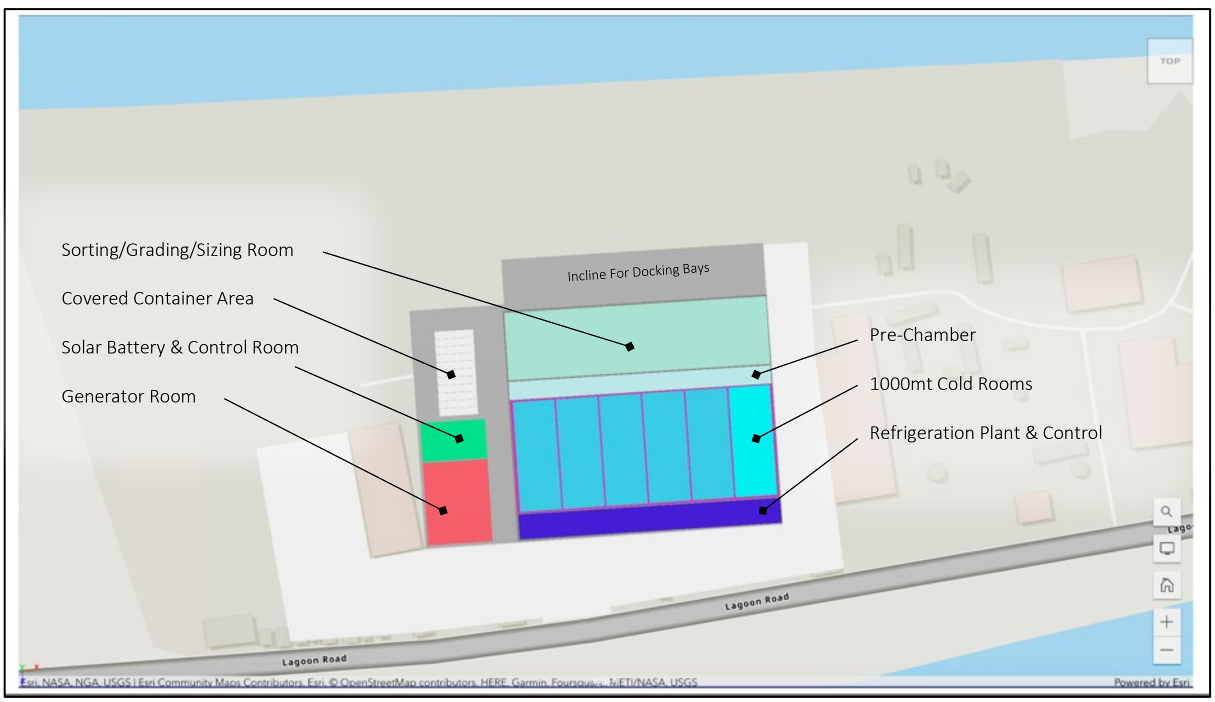
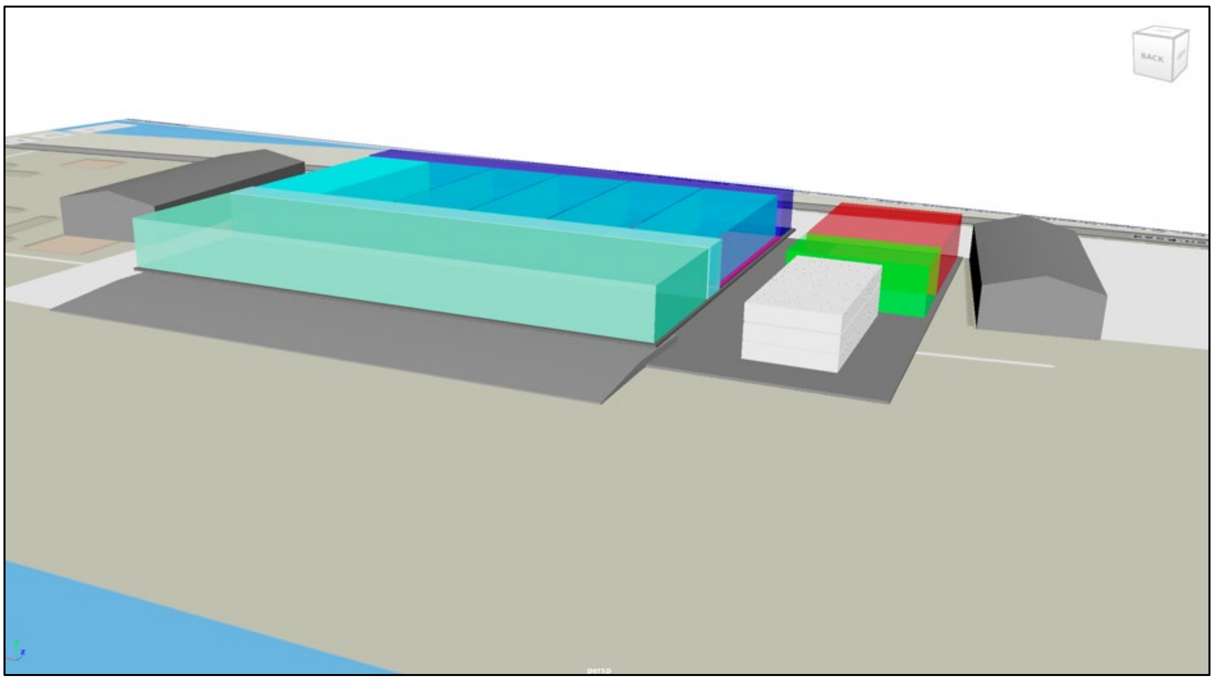


Figure 34. 3D CAD rendering of the proposed cold store facility integrated with data from ESRI Mapviewer

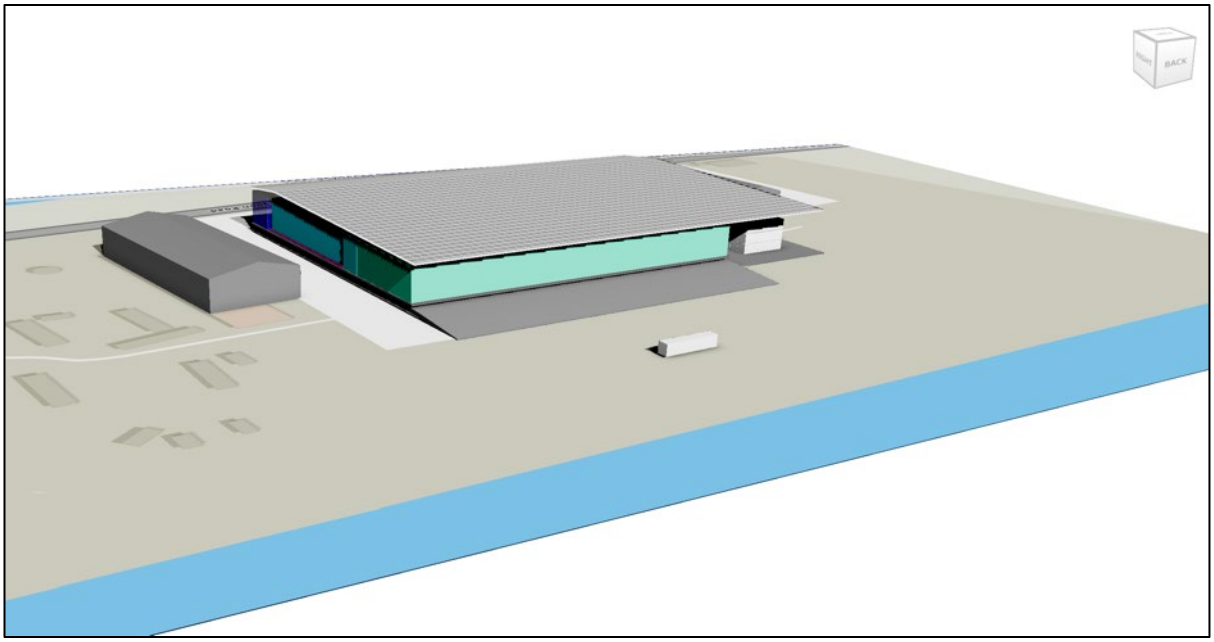


Concrete and civil works

Due to the nature of the mass of the cold store at full capacity (1 000 Mt) it is advisable to pile foundations for areas which are intended for cold storerooms. Additionally, since the substrate consists of coralline accretion, friction piles should be considered over standard end bearing piles as they would not interact with any specific form of bedrock. Piling equipment will need to be considered as an investment as part of the construction process.

Investment costs for civil works is extremely difficult to calculate, particularly as prices fluctuate and construction time is difficult to estimate within the bounds of this study. Estimating the cost of fabrication of one cubic meter of cement can be estimated at over 1 000 USD per m3 (personal communication with Pacific International Inc. (PII)). Considering this estimate, the facility floor, at approximately 120m x 80m, 50cm in volume could cost over 5 million USD alone. Variations in this estimate would depend on specific requirements, for example, friction pile caps, cold room floors, and vibrational considerations for the generator and refrigeration plant room. Note that in the design, these are separated to reduce vibrational interactions which can contribute to increased maintenance. Construction will be the highest investment cost overall and needs a detailed quantity survey to be comprehensively estimated. However, based on past cold store facilities with similar design specifications and volumes of cement required, including inflation of materials since implementation, and including the scaling of these prices relative to the high logistical cost of construction on the Marshall Islands, for the purposes of this study, this construction cost estimated to be in the region of 30 million USD.

Figure 35. 3D CAD rendering of the proposed cold store facility roof integrated with data from ESRI Mapviewer



Phasing of construction

The capacity of cold storage refrigeration equipment (compressors etc) in this study is designed around the implementation of three cold rooms, each of 1 000 Mt in capacity. The following steps are a suggestion for a phased construction.

1. Completion of existent dock extension interventions.
2. All permissions and pre-requisites met by all parties involved, including investors and investment plans and agreements, and all environmental permissions for the construction, granted.
3. Preparation and cleaning of the site.
4. Friction piling foundations for critical load and vibration prone areas (cold rooms, refrigeration plant room generator room).
5. Installation of ground pipework including wastewater services, catchment water tanks, septic tanks and all related ground pipework for amenities.
6. Construction of the generator room, solar battery/control room and road access.
7. Installation of generators.
8. Construction of foundation pillars for the elevated floor for six cold rooms, pre chamber and sorting/grading area.
9. Construction of the base layer of the floor of the cold room, pre chamber and sorting/grading area.
10. Construction of three cold room shells.
11. Construction of the refrigerator plant room.
12. Superior roof construction.
13. Installation of solar panels, control system and battery.
14. Water services installation (pipework and integration of the facility with mains water, water tanks, roof catchment pipework, waste water, septic tanks, power for sorting area, container plug-in area).
15. Electrical services and microgrid installation (ducting, conduits, control systems and integration of the facility including options for mains electrical supply for low voltage utilities, power for sorting area, container plug-in area).
16. Installation of panels, floors, ceilings, doors, curtains, lighting, emergency lighting and alarms for three cold room.
17. Installation of compressors, evaporators and condensers and associated pipework and control systems.
18. Coatings and painting of pipework.

Preliminary environmental assessment of Kramer dock

An earthmoving and preliminary environmental assessment was undertaken for the UN FAO FISH4ACP tuna cold store feasibility project and includes a draft Earthmoving Permit Application (EmPA) and preparation of a draft Preliminary Environmental Assessment (PEA) (available as supplemental documents). This assessment included analysis of a range of scalable scenarios in terms of phased operational levels for the cold store facility and considerations in this assessment which relate to implementation include.

- Analysis of the current status of dredging, reclamation, sheet piling, and seawall.
- Water quality and quantity.
- Terrestrial flora.
- Solid and liquid waste.
- Drainage and sedimentation.
- Erosion and sedimentation.
- Noise, traffic, and air quality including public and worker safety.

The environmental assessment recognises that the cold storage project is dependent on the completion of current active dredging, seawall construction, and reclamation along the Kramer Dock shoreline and further insight into the Marshall Islands Environmental Protection Authority (EPA) permit for these prior activities is needed. This could be achieved by PII report on the current status, expected completion, and mitigation/safeguards of these activities as part of the cold storage Environmental Management Plan (EMP), which is recommended by the PEA. These considerations are integrated into the rationale for the EmPA and PEA.

Figure 36. Aerial view of the Kramer Dock site location

Source: Image courtesy of PII.

Another key intervention, necessary prior to construction interventions proceeding at the site is the site preparation in terms of the removal of equipment and waste currently at the site. This action ensures necessary cleaning has been undertaken for the site and increases the effective amount of area available to expand onshore support services, which include the cold store facility.

Summary of investment costs

The following costs are for a 1 000Mt tuna cold store with capacity to be scaled to 3000MT by additional investment of evaporators, insulation, and doors in two additional cold rooms. This allows the study to inspect threshold points which define the feasibility of investment on the basis of an economy of scale. These costs are integrated in the next section, Operational Feasibility, which assesses these values in terms of depreciation and operational costs.

Costs	Amount (USD)	Sub Totals (USD)
A. Cold Store Infrastructure Costs		
Tuna Bins	1,000,000.00	
Evaporators, Condensors, Insulation, Pipework, Coatings	150,000.00	
Compressors & Control Equipment	160,000.00	
Paneling, Flooring, Fixtures & Films	90,000.00	
Generators	150,000.00	
Transformers	40,000.00	
Fans & Safety Equipment	50,000.00	
Micro Grid Control Equipment	50,000.00	
Forklift	80,000.00	
Sub Total Cold Store Infrastructure		1,770,000.00
B. Construction Estimate	30,000,000.000	
A + B (Sub Total inc. Construction)		31,770,000.00
C. Renewables		
Half Roof Solar Coverage	500,000.00	
Solar Battery Storage For Half Roof	250,000.00	
Renewables Subtotal		750,000.00
Estimated Grand Total		32,510,000.00

Operational feasibility

While the logistics of implementation provide a valuable background to understanding operational costs, the method of generating revenue and so an income from a cold store requires a range of considerations. This also determines the scale of the project, and while specifications in the previous section identify a modular plan for implementing a cold store of 3 x 1 000Mt cold rooms, it should be noted that the quantities calculated are per 1 000 Mt cold room as it is intended that, based on implementation costs, operational costs, revenue and profit, the scale of the project can be scaled back as small as one 1 000Mt cold store should it be deemed necessary.

However, there are some fundamental considerations which relate to the method by which revenue is generated and these considerations will have influence on the feasibility of the investment. Fundamentally, if we base the business model on the container-based approach, in that, when there are landings, there is revenue, the risk of investment becomes completely dependent upon landings and this level of uncertainty does not validate any investment as it does not provide any guarantee of returns. However, there is a model approach which does not depend upon this risk factor, and that is to base the investment on guaranteed rental of volume of the cold store to clients. From a financial perspective, this is the recommended way to assure investors of the feasibility of their investment and, as previously mentioned, is the method by which the CCCS on the Seychelles operates their 12 600Mt cold store facility and they approach they used to finance it. However, there was a fundamental driving factor in the Seychelles which validated the demand cold store operation, in that the CCCS was completely validated due to.

- Enable landings within the Seychelles and greater efficiency in terms of fishing effort.
- The push factor of incoming the European Union mandatory regulations on catch composition.
- The proximity of the Thai Union cannery on the Seychelles.
- Sorting, grading, and sizing enabled an improved return of around 10 percent per container.

Currently, in the case of the Marshall Islands, landings are already feasible, there are not incoming mandatory regulations which validate the use of a cold store and there is no key processing facility which necessitates a cold store, and added to this, the transhipment and containerization model works very well in the Marshall Islands to satisfy the needs of the stakeholders and their logistics.

So, in order to scope whether if the cold store could be operationally feasible, prior to any investment, we need to ask the fundamental question, who are interested clients that can guarantee rental of the storage space and facilities, what services do they require to meet their needs, and, most importantly; how much can each identified client guarantee, as a binding agreement, that they will to rent over a given period of time which validates the return in investment?

While there are many positive ideas spanning technical, environmental, sustainable, risk based and in terms of economic calculations related to the construction of a cold store facility, without these commitments, the cold store facility remains a hanging on a "build it and they will come" financial model, which, considering the scale of the investment, does not make a sensible economic rationale for investment.

Doing business in the Marshall Islands

According to the World Bank "Doing Business Report 2020", the Marshall Islands' business environment ranked in the lower quarter at 153rd position out of the 193 countries assessed in terms of the overall ease of doing business. However, while this is below the average ranking of Pacific Island countries, it compares favourably with the Federated States of Micronesia (158th) and Kiribati (160th). Among the 10 dimensions which measured the ease of doing business, the lowest ranking factors constraining the Marshall Islands' score include registering property, protecting minority investors, resolving insolvency, and access to electricity and credit. Although issues relating to services are addressed in this study, legal guidance is recommended for stakeholders involved in any proposed consortium, partnership, or any other arrangement, in whatever form, spanning issues around investment, land tenure, investment rights and other related agreements.

Pre-operational costs

Due to the technical aspects of running infrastructure relate to both the micro grid and the cold store operation, sufficient training is considered critical for prospective staff. Training should be considered as a critical investment in terms of mitigating depreciation and operational costs. Additionally, retention of trained staff should be an important consideration both in terms of salaries and selection criteria when identifying potential candidates for key roles in the cold store facility. An assessment of human resources currently involved in the tuna landings and processing on the Marshall Islands is advisable alongside ensuring that gender and equality considerations are integrated into any staff selection process. Additionally, an in-situ assessment of existing human resources retention and loss can play a vital role in identifying both operational efficiency and what characteristics of employment in this sector are considered critical characteristics of job satisfaction.

In terms of technical implementation of the cold store infrastructure, it is advised that an experienced external supplier is hired, ideally linked to the procurement of insulation panelling and refrigeration plant infrastructure, to supervise local staff in installation of the facility. This ensures that the components are assembled correctly and can assist in any detailed construction planning processes, particularly for specific requirements of the cold room floor, walls and ceiling and refrigeration plant room construction. This approach also applies to micro grid infrastructure, operational and safety training, and some providers such as Schneider Electric (Energy University) and Danfoss (Refrigeration control systems through to food HACCP) have specific programs for electrical engineer training which incorporate an SDG based approach including gender considerations. Investment in contemporary cold store management systems also has key benefits in terms of data collection and remote monitoring which can contribute to commodity traceability and certification processes.

This training also enables further investment based on knowledge and experience gathered by retained staff to contribute to any future modular expansion.

Cost considerations - pre-operational costs

Installation supervision and training of local workforce to implement cold storeroom and refrigeration plant infrastructure is estimated to require two specialist engineers at around $550 USD per day including accommodation and per diem, a total cost for 30 days in the region of $40,000. Refrigeration plant, cold store and microgrid training is available both online and in person and costs are estimated at 100 000 USD for eight prospective staff.
TOTAL COST; 140 000 USD

Operational environmental assessment

The preliminary environmental assessment (PEA) conclusions identify that the EMP should also contain the quantitative resource consumption footprint of the post-development operation of the cold store facilities and include both infrastructure and disaster risk management and mitigation actions. This feasibility study provides a resource in terms of consumption information and options for additional information should it be required for example, should a prospective the Marshall Islands EPA additional concerns which need to be addressed in the EMP.

Climate change and inundation/flood risk assessment of the Kramer dock

All cold storage load calculations in this study have been made on the basis of upper ranges of current ambient (wet bulb) temperatures. However, climate projections vary and indicate increases of around 1.5°C over the next 10 years. This will have critical implications in terms of aspects such as transmission loads of any storage volumes and has been built into this study by calculating power consumption and costs on the basis of the upper 30% contingency factor.

Another key consideration related to extreme weather events is that the superior roof design should include precautions to prevent pressure build up (Bernoulli's principle) on the underside of the building during high wind speed events. This can be assessed in structural design plans and simulations. Although beyond the scope of this study, structures such as baffles and curbed roof ends, on the underside of the roof are measures to mitigate this risk and improve the resilience of the structure. Additionally, high wind speed should be a consideration in solar panel installation and fixings and associated infrastructure should use a precautionary approach in order to mitigate loss of panels during extreme weather events.

Panel installation should also be a consideration in any simulation as the angled panels may promote high velocity air flow in one direction (e.g., at 180-degree azimuth, southerly winds) and reduce velocity however absorb airflow energy, in the opposite direction. Fundamentally, damage identified in FAO post disaster assessments of coastal fisheries value adding and cold store facilities is most commonly related to loss of roof infrastructure, consequential loss of solar PV panels and subsequent damage to internal infrastructure and assets, particularly from aerosol saltwater corrosion following a surge/extreme weather event (personal post disaster observation). This scenario is particularly noted when roof loss over tall void buildings constructed from low quality/ratio cement, and/or cement mixed with saline aggregate (rather than e.g., volcanic aggregate), resulting in low pressure chimney effects inside voids, and consequentially, walls collapsing inwards.

Added to this, sea level rise and related implications of climate disaster risk need to be considered. From a design perspective, the cold store facility in this study has been elevated both to mitigate frost heaving through use of passive airflow, but also this elevation has an additional benefit as a measure to ensure that the facility is less prone to damage from extreme weather events such as surge waves and high wave runup. Locating the cold store beyond a 60m buffer from the coastline and completed dock extension is also another key consideration in mitigating this risk.

Existing published/available inundation studies for Majuro have not focussed on the proposed site and frequently do not address smaller increments of mean higher high water (MHHW) levels. Assessment of smaller increments which are more probabilistic in terms of scenarios faced within the lifespan of the investment are valuable in terms of determining location feasibility and were a fundamental consideration regarding site identification. In order to generate relevant site-specific data, inundation models were re-assessed specifically for the site in conjunction with USGS.

Projected exposed areas for three marine inundation levels, 15, 30, and 45 inches are provided in this study based upon the USGS DEM dataset and prior research (Gesch D. P.-L., 2020; Gesch D. D.-L., 2019; Palaseanu-Lovejoy M. P., 2018; Palaseanu-Lovejoy M. P., 2017). Inundation modelling starts from the (white) MHHW line where areas have been mapped above the elevation of this line. The results show three inundation scenarios from the probabilistic modelling approach, which accounts for known uncertainty (vertical error) in the DEM, so the indicated areas have a 95% chance of being inundated or are 95% certain "extremely likely" at the given water level, from the DEM data. The white line is the mean higher high water (MHHW) shoreline derived from records at the Majuro tide gauge and mapped from the DEM.

Figure 37. Results of probabilistic inundation mapping showing the areas with a 95 percent chance of inundation with a 15-inch water level increase above the MHHW shoreline

Figure 38. Results of probabilistic inundation mapping showing the areas with a 95 percent chance of inundation with a 30-inch water level increase above the MHHW shoreline.

Figure 39. Results of probabilistic inundation mapping showing the areas with a 95 percent chance of inundation with a 45-inch water level increase above the MHHW shoreline.

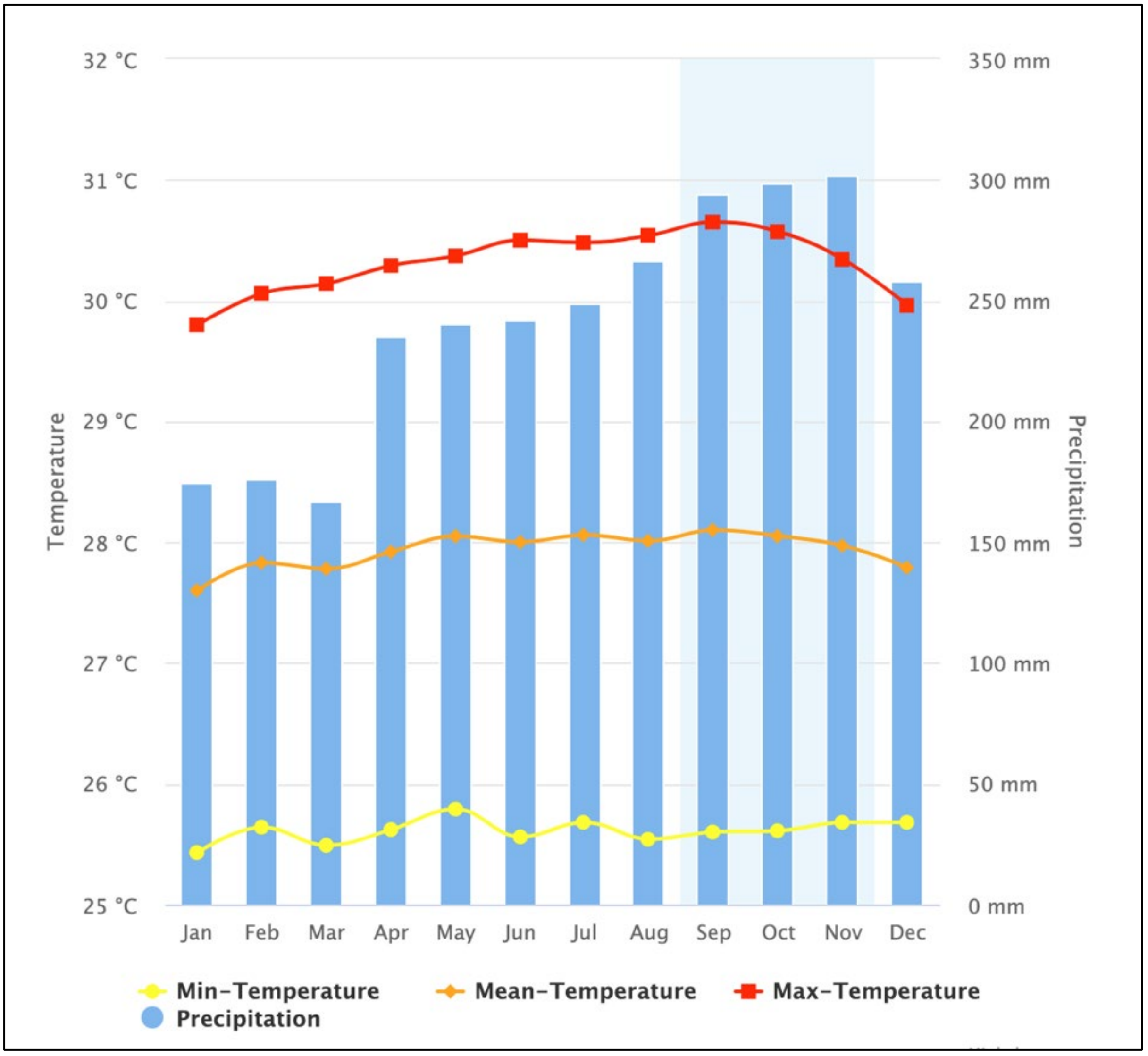
While the prediction modelling is a useful guide, it is important to note, that these inundation grids present conservative (high-risk) inundation scenarios as they are based on a digital elevation model which does not account for ongoing current dock extension interventions. This is also the case for any other modelling based upon available data and past studies and for an accurate assessment of the proposed site. It may be that the DEM can either be modified to represent the completed dock intervention or it may be worthwhile gathering new, high-resolution site-specific data in order for any assumptions to be mitigated upon completion of the current dock developments, prior to proceeding with any construction. Locating the cold store beyond a 60m buffer from the coastline and completed dock extension is also another key consideration in mitigating this risk, however it can be seen from the 45-inch inundation model, that the eastern side of the site location presents clear risks and the need for construction considerations. This is particularly the case considering the probabilistic modelling approach can be applied to event based inundation conditions such as extreme surge and high wave runup (Gesch D. P.-L., 2020; Gesch D. D.-L., 2019; Palaseanu-Lovejoy M. P., 2018; Palaseanu-Lovejoy M. P., 2017).

Water

In Majuro, between 300-340cm of rain fall per year (World Bank, 2022), with a minimum of 180 mm in February and a maximum of 360 mm in October. During El Niño periods, rainfall decreases significantly from January to April, and also sometimes in May. During this period, only 115 mm of rain fell in 1983, 70 mm in 1998 and 195 mm in 2016.

We can calculate potential rainfall catchment of the roof of the cold store facility on the basis of the equation; annual rainfall (in millimetres) x roof surface area (in square metres) = roof catchment capacity in litres. If we consider the average rainfall over a normal year at the lowest average estimate of 300cm, this volume is 28 800 000 litres or 28 800 m3 per year and 2 400m3 per month.

Figure 40. Monthly climatology of minimum temperature, mean temperature, maximum temperature and precipitation, 1991-2020 for the Marshall Islands



Source: World Bank Climatology (World Bank, 2022).

Estimated water volume for a cold store facility only undertaking sorting, grading and sizing and undertaking key activities, such as washing down your loading areas, washing tuna bins, and cleaning equipment, can be calculated on the basis of 0.02381m3 of water storage required per ton of capacity (personal observation from a range of fisheries cold store operators). For a 1000MT cold storeroom, this equates to 23.81m3 if water storage.

Considering the capacity for roof catchment exceeds the demand, and with the prospect of upscaling the operational capacity to 6 000Mt and considering the scarcity of water at the site location, it is recommended that storage for 150m3 or water is built into the detailed design plans. From existing information, it appears that there are two existing water tanks at the site, however the capacity is unknown.

Risk assessment recommendations

This section is designed as a recommended range of operational interventions necessary to mitigate some of the most common cold store facility risks. It is critical to think systematically through the hazards in the cold store and implement the steps needed to take to control the risks and formulate a compressive strategy to mitigate them. These span from extreme cold, accidental release of e.g. ammonia refrigerant, workplace transport, slips and trips, falls from height, falling goods, machinery, pallet inverter, recharging batteries, noise, electricity, unfamiliarity with site risks and a comprehensive fire prevention plan. Emergency lighting and panic buttons are essential, and special considerations and measures should be made for working in hazardous / oxygen deficient atmospheres, working in isolation, and personal protection equipment (PPE) for exposure to cold.

Access to the store should be restricted to authorised, trained persons only, with 'No entry' signs clearly posted, and emergency exits should be provided, with doors fitted with strip heaters to ensure they do not freeze. There should be daily checks of these doors and all alarms and emergency lighting should have routine checks and maintenance from a competent person.

Emergency lighting provided should be mains powered but with a battery back-up, and emergency exit door instructions should be clearly lit and referenced to all staff. There should be two trapped worker alarms (battery operated, mains back-up) next to all exits. Checks of the buildings should be made before exiting and locking them by a designated person.

Employees should be health screened before working in a sub-zero environment and there should be regular checks and a precautionary approach to deteriorated health of personnel, particularly if cold stress is identified. All staff should be trained to recognise the symptoms of cold stress and injury (e.g., frostbite) as extreme cold can also lead to gradual loss of awareness to risk through perceptual narrowing.

Correctly fitting PPE should be given to staff working in extreme cold environments, which should be checked and maintained or replaced regularly as needed.

Figure 41. Cold store forklift with closed heated cabin and PPE

For use of Ammonia refrigerant, rapid ATEX grade fans should be installed at the plant and vapour detectors should be installed in conjunction with ventilation and a systematic scheme for both plant maintenance and examination of all safety devices should be maintained at least monthly by competent personnel. Vapour detectors should be positioned near likely leakage points so as to activate alarms and emergency extraction systems if a workplace exposure limit of 25 parts per million reached.

It should be remembered that prolonged exposure to Ammonia may result in fatal respiratory irritation and that exposure to even low concentrations can cause severe eye and throat irritation. All staff should be made aware of the potential risks of Ammonia and an Emergency plan for ammonia release drawn up and trained to all staff and drilled at the site, including victim rescue and policy for neighbouring properties, and this should include discussions and involvement with local fire service. Water showers should be at known access points nearby (including regular checks) for those exposed to an ammonia spray and a windsock should be positioned so staff can evacuate upwind of any leak.

During maintenance, any work on the system where there is a potential for ammonia release should be undertaken by at least two people, the second person to assist in an emergency. A comprehensive risk assessment should also include considerations for vehicle activity on the dock, loading docks, and internal vehicle operations.

Operation costs

Estimated operational costs are calculated for one 1000MT cold store and all related operational infrastructures. In order to logistically move tuna to the cold store from vessels, a certain amount of infrastructure is required. On the basis of the star loader improving efficiency for offloading tuna, this equipment is deemed a necessary component of the cold store infrastructure, along with sorting conveyors which are necessary for value adding activities (sorting, grading, and sizing). In order to make an estimate of operational costs of these logistics, we can assume that the maximum offloading rate determines the overall conveyor rate. The energy required can be estimated at a rate in the region of 24 tons of tuna per hour, with a density of approximately 500kg/m3 and a total distance from dock to the cold room of 100m and belt width of 0.82m with the additional assumption of a capacity of 0.12t/m of tuna on the conveyor. An estimate of the energy required is around 8kWh per 24Mt and 334kWh for 1 000Mt, taking a total of around 42 hours of continuous operations to fill the cold store. From this approximate estimate, we can build in a relative cost of logistics, that for every ton added to the cold store, an additional 0.33kWh of energy is needed. If Majuro grid energy is used for this, we can assume that the overhead cost of moving the tuna to the store requires an additional 0.12 USD per Mt. Costs for this infrastructure need to be added to the total cost for the cold store facility, however this may be absorbed to an extent by existing procurement plans to implement star loaders for containerization.

From previous cooling cost calculations, these figures can be built into the operational costs and the following estimate calculations for operational feasibility are provided for high operational use based on maximum capacity of 1 000Mt.

Workforce costs are estimated based on current available data from operational tuna cold stores in the region (Kosrae) to be around $6.94 USD per MT of tuna per employee per year at a rate of 0.05 employees per MT. At maximum capacity, this equates to a total of $347,000.00 USD per year at maximum capacity all year round. Taking a precautionary approach, a further 30% is added to this which equates to $451,100.00 USD per year.

Any land rental costs should be considered on the basis that the facility needs to improve the efficiency of the storage capacity of containerization, i.e. where reefer containers are stacked 3 high, the footprint is 12.2m x 2.4m at around a total of 75 tons. This equates to the cost of the footprint of containerized tuna for stakeholder rental is $0.39 USD/m2.

Total electrical costs are estimated for 1000MT of tuna, including a contingency factor for stock changes at 30 percent to be 365 949 USD annually based on power sourced from the Marshall Islands grid. Other costs are calculated, for example, maintenance and repairs, on the basis of operational use proportions using current data from Global Cold Chain Alliance quarterly reports (Alliance, 2022) and adjustments for the higher cost of electric on the Marshall Islands and factoring in remoteness in terms of sourcing parts.

Table 3. Operational costs based on the study for a cold store running at maximum capacity

Operational costs	Amount USD	Totals
A. Estimated Operational Costs PA		
Refrigeration Electric – RMI Grid	365,949.00	
Workforce Costs	451,100.00	
Maintenance & Repairs	109,702.00	
Unexpected costs, expenses on utilities other than electric power, and un-specified other expenses.	24,379.00	
Total A.		$841,446.00
Depreciation		
B. Depreciation Equipment		
Tuna Bins	40,000.00	
Electrical & Cold Store Infrastructure	40,920.00	
Generator Equipment	45,000.00	
Total B.		$150,920,00
C. Depreciation Renewables (100% over 20 years)	$37,500.00	
Total C.		$37,500.00
Total A + B + C		$1,029,866.00
D. Building Depreciation	1,500,000.00	
Total D.		$1,500,000.00
Total Costs (A + B + C + D)		$2,529,866.00

Depreciation rates

- The overall estimated lifespan for the proposed cold store facility is estimated at a maximum of 20 years.
- Tuna bins specified have an estimated lifespan of 40 years, at a total cost of 1 million USD so the depreciation rate is estimated at 4 percent.
- Electrical equipment is estimated at 6.66 percent depreciation.
- Generators for non-emergency purposes 30 percent
- Buildings are calculated at 100 percent depreciation rate over the lifespan of the facility, and it should be noted that this cost is estimated on the basis of an estimated build cost of 30 million USD.

Conclusions

The operational cost calculations presented are intended to encourage discussion around both the operational costs and the implementation costs. From the previous section, it can be estimated that the cold store facility runs at a total cost of 2 529 866 USD per annum and this equates on the basis of volume cost over a year of 1 000Mt, to a cost of just over 6.93 USD per Mt of tuna per day with one cold room, running continuously, at maximum capacity. Clearly, this is not competitive in comparison to containerization.

However, we can adjust the volume of the cold store with a very slight increased investment in terms of adding insulation and fittings for two more rooms, as the refrigeration configuration specified in this document accounts for a capacity of 3 000Mt. This improves the daily cost of storage of one MT of tuna to around $2.40 per MT, if the cold store rooms are at maximum capacity 365 days per year.

Both these calculations do not account for energy generated from solar, and if this is integrated into these calculations at a conservative cost saving benefit of 70 percent of the power consumption, this results in costs of $6.24 USD per Mt at 1 000Mt capacity and $2.16 USD per Mt at 3 000Mt capacity. An additional consideration which may be favourable is if fuel supplied to generate electricity for the cold store could be tax exempt, as is the case, for example, with the CCCS cold store on the Seychelles.

It is also important to consider that the estimated build cost at $30 million USD plays a significant factor at 70 percent of these costs, through the depreciation calculation. However, these figures have been prepared in order for the information in this document to be used to enhance more detailed construction plans and quantity surveying which should identify more specifically how much this cost will contribute to this financial assessment.

If we calculate profit on the basis of an equal cost to the client of containerization (worst case profit model) at $3.13 per Mt per day, it is clear that a 1 000Mt facility is not feasible. However, at 3000MT capacity there is room for a profit margin which is feasible. The worst case for this, equalling containerization yields an annual profit of 897 484 USD per annum which, over a 20-year period, not accounting for inflation, only yields a return on investment of 17 949 280 USD. However, also not accounting for inflation, during this period, the cold store also returns in excess of 9 028 000 USD back in terms of workforce income and therefore into the local economy.

An additional consideration in these calculations is also the value added in terms of sorting, grading, and sizing activities undertaken within the controlled environment and the potential to maximise profits through sales of stock during periods of higher pricing. If we estimate these activities on the basis of figures from the CCCS in the Seychelles, this has the potential to improve profits by 10 percent to 20 percent per Mt. Conservatively estimating that, over a year, the total volume of the cold store is stocked and retrieved three times, i.e. 9 000Mt passing through per annum (equivalent to approximately 375 containers), this equates to 14 400 000 USD of tuna at an estimated value of 1.6 USD per kg, and therefore, the cold store has the potential to have added 1 440 000 to 2 880 000 of value.

From these calculations, it is clear that the margins for feasibility between running at 1 000 Mt and 3 000 Mt capacity yet again demonstrate the concept of an economy of scale. However, all these calculations rely upon clients renting cold storage space for a guaranteed period of time. Low storage costs, and the prospect of adding value through sorting, grading, and sizing in a controlled environment, alongside the potential to have a greater stake in market value, are the key incentives to attract clients.

So, we can summarise that the operational concept in that opportunities to validate investment rely upon identifying.

- A construction cost which lowers the investment and depreciation values calculated.
- Where losses through a lack of access to a controlled environment for sorting, grading, and sizing are worthwhile mitigating through use of a cold store for intermediate storage of sorted, graded and sized stocks prior to containerization. (e.g., containers are paid for on the basis of the majority of the contents, and the remainder is rejected by the buyer).
- Where the price point for cold store volume rental is lower than containerization for storage AND the logistics of stuffing containers for carriers from the cold store are efficient enough to validate the cost of sorting, grading, and sizing.
- Where cold storage becomes cost effective in terms of holding sorted stock during price dips to enable greater returns during high demand from buyers.

Should these criteria not be met, or some other formulae be proposed, another option for the Marshall Islands to add value could be to empower containerization on Majuro by investing in some of the infrastructures presented in this study, perhaps on a different scale and location, and integrating them with improved efficiency of landing logistics (e.g. through investment in dockside logistics such as star loaders, as is currently planned by MIMRA). Suggestions which this study proposes include.

- Investment in a controlled environment for sorting, grading, and sizing.

- Building a 12m high roofed area which.
    - reduces reefer container power consumption,
    - reduces risk of reefer container failure,
    - generates daytime solar energy,
    - and creates a water catchment opportunity.

- This also opens up opportunities to assess potential investment in solar energy storage, which could improve the efficiency of containerization however this has a relatively high investment cost and would require reworking of details and scales of, for example power consumption and some level of validation through increased volumes of containerization.

From field work interviews, it appears to be clear that there is high interest from a few key stakeholders who are already keen to pursue a cold store at the Kramer Dock, including from the existing operation on Kosrae, and the probability that a partnership will be, or has been created already, between the stakeholders, to move forward with construction, is high. Also, throughout this feasibility study, representatives from Walmart, have collaborated in discussions and meetings relating to their need to create sustainable supplies of tuna from the region with a reliable level of traceability. With this existing level of interest, it is hoped that this study offers solutions and recommendations which are either useful suggestions or complement existing design ideas.

Additionally, the study has been somewhat limited in terms of prior identification of sites, and, in line with the Government's objectives for urbanization and expansion in the islands, it may be that the design concepts from this study can be useful for their plans for expansion in other areas. One example noted during the research stage of this study, is that it is believed that there is a heat pump project for energy in another location which could have the potential to be integrated with a cold store as the physics of utilizing deep seawater for cooling present significant cost cutting benefits for condensing refrigerant.

Perhaps another benefit which can be empowered from the concepts in this study is to draw from the principles and provide lower cost smaller scale cold storage for a broader range of fisheries stakeholders and also integrate storage of other perishable commodities, such as vegetables, rather than focusing on one sector. Both of these sectors have clear benefits for nutritional culture on the Marshall Islands and have potential to empower a broader diversity of stakeholders through a broader base of public private partnerships, perhaps even taking inspiration from the Combined Community Cold Store model. This type of approach has the potential to both distribute the wealth from investment more equally, and also ensure a broader access to services. This approach may also generate more interest from potential donors, rather than a focus on one specific sector.

As an afterthought, it is important to bear in mind that examining the effects of any upscaling of capacity is a useful exercise in terms of fisheries adaptive management and the sustainable use of resources.

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ANNEX

REPUBLIC OF THE MARSHALL ISLANDS
ENVIRONMENTAL PROTECTION AUTHORITY
P.O. Box 1322 Majuro, Marshall Islands 96960
Phone: (692) 625-3035/5203
Email: rmiepa96960@gmail.com

PRELIMINARY
ENVIRONMENTAL ASSESSMENT – PEA

1. Instructions for Coastal, Land, and Conservation Division

-Read current version of the "Environmental Assessment in the RMI" document.
-Assessor delegated by the Division Chief or GM to carry out the PEA.
-No PEA or any project assessment is carried out before the permit fee is paid.
-Although most PEAs follow Major EmPAs, some may be assigned from Minor EmPAs.
-All projects affecting the intertidal/subtidal marine environment require a minimum of snorkeling reconnaissance.
-PEA is incomplete/unaccepted until the recommendations page is signed by the assessor, Division Chief, and GM.
-There is no need to repeat project specific information from the EmPA in this PEA, except for items within the impact/mitigation table that need to be organized so that permit conditions can be clearly outlined in the next stage of the assessment process.
-For any revised boundary or turbidity curtain/containment requirements, provide a new drawing on the last page.

2. Project Reference

Name of Applicant: __ Kenneth Kramer/PII_______ Name of Project: _Tuna Cold Storage Facilities and Associated Infrastructure at Kramer Dock_

Date of Application: _________________________ Minor/Major Project: _Major___________________

Site Photos [Trees of the RMI illustrations from Vander Velde, 2001]

Photo 1

from ocean side of road at PII entrance looking N to lagoon side

Photo 2

from inside PII entrance looking N

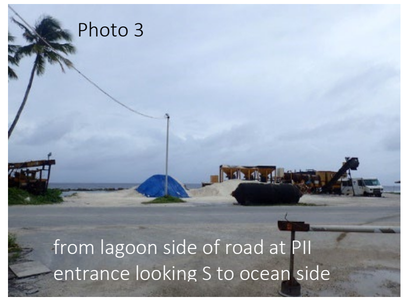


Photo 3

from lagoon side of road at PII entrance looking S to ocean side

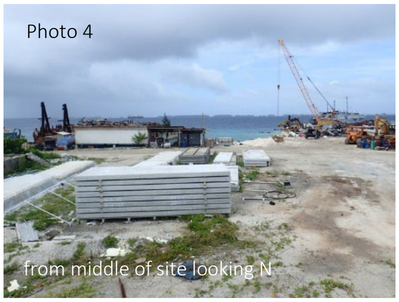


Photo 4

from middle of site looking N

Photo 5

from middle of site looking S

Photo 6

from middle of lagoon shore looking S

Photo 7

from middle of site looking E

Photo 8

from middle of lagoon shore looking N

Photo 9

from middle of site looking W

Photo 10

from E end of lagoon shoreline looking S

Photo 11

from E end of lagoon shoreline looking SW

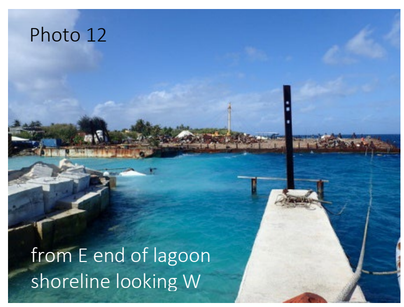


Photo 12

from E end of lagoon shoreline looking W

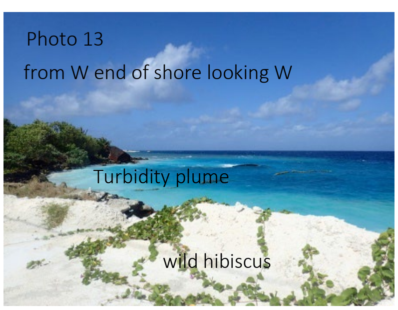
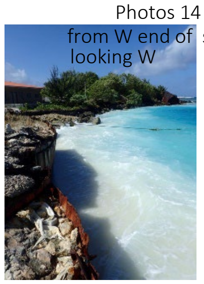
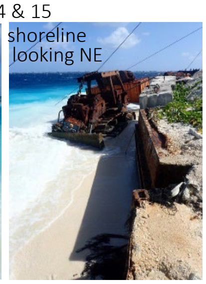


Photo 13

from W end of shore looking W

Photos 14 & 15





from W end of shoreline
looking W | looking NE

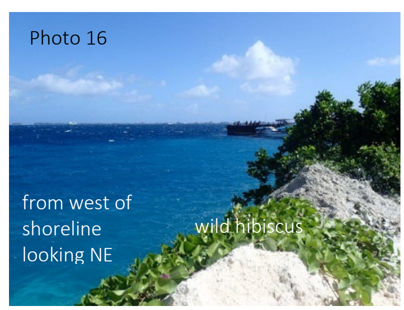


Photo 16

from west of shoreline looking NE


Photo 17
crane with dragline at W end of shoreline
Photo 18
active dredging at west end of shoreline
Photo 19
from middle of shoreline looking NW
wild hibiscus
Photo 20
from ocean side shore looking E
Ni – Coconut
Photo 20a
Photo 20b
unidentified palm
Photo 21
at ocean side high water mark looking E
Photo 21a
salt protector
Photo 21b
important import
Photo 22
from ocean side shore looking W
Photo 22a
common
Photo 22b
important import
Photo 23
at middle of site
Photo 23a
common
Photo 23b


Photo 24
at middle of site, introduced Australian Pine (Coastal She-oak, *Casuarina* sp.)


Photo 25
from SW of site looking SE


Photo 25a
introduced Australian Pine (Coastal She-oak, *Casuarina* sp.)


Photo 26
from SW of site looking E


Photo 26a
Lukwej – Beauty Leaf
Calophyllum inophyllum
Mangosteen Family – Clusiaceae


Photo 26b
important import
Lukwej – Beauty Leaf
Calophyllum inophyllum
Mangosteen Family – Clusiaceae


Photo 27
from W of site at water tank looking E

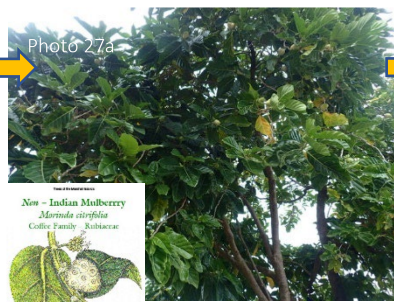


Photo 27a
Non – Indian Mulberrry
Morinda citrifolia
Coffee Family – Rubiaceae


Photo 27b
important import
Non – Indian Mulberrry
Morinda citrifolia
Coffee Family – Rubiaceae


Photo 28
introduced papaya
from W of site at water tank looking NW

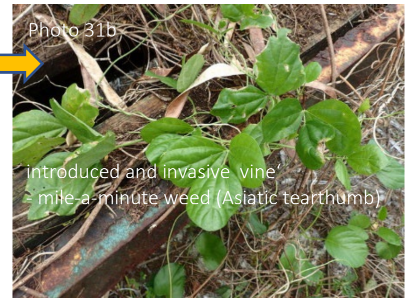

Photo 29
from W of site at water tank looking N
banana

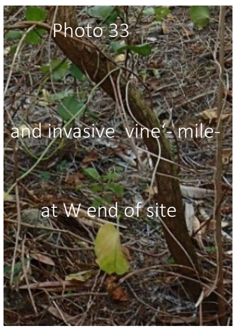

Photo 29a
Ni – Coconut
Cocos nucifera
Palm Family – Arecaceae
major agricultural tree

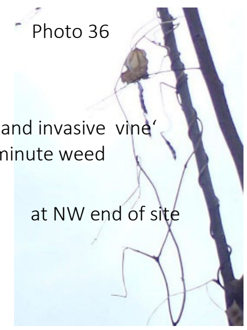

Photo 30
Bōb – Pandanus
Pandanus tectorius
Pandanus Family – Pandanaceae


Photo 30a
major agricultural tree from W of site at water tank looking N


Photo 30b
Bōb – Pandanus
Pandanus tectorius
Pandanus Family – Pandanaceae







Site Visits & Meetings

Feb 1	- Meeting with Kenneth and Jerry Kramer, PII. - First site visit; walk-around.
Feb 2	- Second site visit; walk-around w/ general photos of site and shoreline, with local consultant Mark Stege. - Meeting with Melvin Kilma and Moriana Phillip, RMI EPA for approval of proposed resolution to the non-renewal of dredging, reclamation, and seawall construction not included in this EmPA. Permit to be renewed.

	- Second Meeting with Jerry Kramer, PII to gather project details relevant to EmPA. Few details are available, especially in regards to the additional buildings and infrastructure to be built to support the cold storage facility.
Feb 5	- Third site visit to carry out terrestrial flora survey. There are few varieties of ecological value, so survey will be part of PEA table instead of in a separate report.
Feb 27	- Second meeting with RMI EPA to go over early draft of PEA.
Mar 3	- Third meeting with Kenneth and Jerry Kramer to follow-up on additional design or EmPA information.

3. <u>Earthmoving/Construction Phase Impact and Mitigation</u>

*For each applicable environmental resource potentially affected by the works (state Activity numbers from application), describe what the effect is on the resource; magnitude (size) of the effect without mitigation; the proposed mitigation measure (applicant commitment and EPA requirement) to be carried out; and the residual magnitude of the effect after mitigation. An example is provided for each resource, followed by space for the assessor to either copy, adapt, or leave blank. Note that a residual magnitude that remains higher than negligible (Ng) must either require additional restoration or be deemed an acceptable tradeoff without restoration.

Magnitu	Meaning
Blank	No harm; non-existent.
Negligibl e (Ng)	Only very minor harm over small areas, which can easily be restored by natural processes.
Low (L)	Some harm but generally only over small areas that is capable of being restored with a small amount
Medium	Harm that is capable of being restored with some effort and time.
High (H)	Harm that occurs over a large area that will be difficult to restore without considerable effort, money
Very	Widespread irreparable harm.

Resource	Pressure & Impact	Effect	Pre-size	Mitigation Response	Post-size
Environmental resource impacted by the works	Change in this resource due to the works	Consequence of the change in the resource due to the works	Magnitude of the effect with no mitigation	Measure used to mitigate/minimize the harm	Magnitude of the effect with mitigation

Resource	Pressure & Impact	Effect	Pre-size	Mitigation Response	Post-size
Environmental resource impacted by the works	Change in this resource due to the works	Consequence of the change in the resource due to the works	Magnitude of the effect with no mitigation	Measure used to mitigate/minimize the harm	Magnitude of the effect with mitigation
e.g. Fresh Water -Quality	*Aquifer & water infrastructure damage; sedimentation, salt water, & chemical/metal*	*Unsafe to drink; unpleasant odors*	*VH*	*Contain works & contamination source; treatment of water; collaborate w/ MWSC/KAJUR/Local Govt.; comply w/ RMI EPA freshwater quality regs*	*Ng*
Activity # _7_ Fresh Water Qual., utility hook-up	sedimentation, salt water, & chemical/metal contamination; algal growth	Unsafe to drink; unpleasant odors	L	Contain works & contamination source; collaborate w/ MWSC; comply w/ RMI EPA fresh water quality regs	Ng
Activity #s _7,8_ Fresh Water Qual., private supply	sedimentation, salt water, & chemical/metal contamination; algal growth	Unsafe to drink; unpleasant odors	M	Contain works & contamination source; comply w/ RMI EPA fresh water quality regs	Ng
e.g. Fresh Water -Quantity	*Aquifer & infrastructure*	*Insufficient or loss of*	*VH*	*Contain works; collaborate w/ MWSC/KAJUR/Local Govt.*	*Ng*
Activity # _7_ Fresh Water	reduced water flow; evaporation	Insufficient or loss of	L	Contain works; collaborate w/ MWSC	Ng
Activity #s _7,8_ Fresh Water	reduced water flow; evaporation	Insufficient or loss of	M	Contain works	Ng
e.g. Salt Water -Quality	*Sedimentation or other physical/chemical/erosion disturbance; algal growth; loss of water column habitat/ chemical & biological function*	*Unsafe to swim; loss of foraminifera & coralline production/coral spawning*	*H*	*Contain works & contamination source; modified boundary sketch; properly deployed turbidity curtain (70% shade cloth, weighted at bottom, floated/sealed at surface, extended to substrate); works limit 2hrs. before/after low tide; calm waves; comply w/ RMI EPA marine water quality regs*	*Ng*

Activity # _7_ Salt Water-Qual., intake for salt water flush	Sedimentation or other physical/chemical/erosion disturbance;	Loss of access	L	Contain works & contamination source	Ng
Activity #s ______ Salt Water -Quality	N/A	N/A	N/A	N/A	N/A
e.g. Marine Flora (good macroalgae, seagrass, mangrove)	*Sedimentation or other physical/dredging/excavation chemical/erosion disturbance; loss of habitat/cover/shade / chemical & biological function*	*loss of nursery/ fisheries/coralline/sand production; loss of shoreline protection/ carbon sink; reduced pH buffer*	*VH*	*Contain works & contamination source; modified boundary sketch; properly deployed turbidity curtain (70% shade cloth, weighted at bottom, floated/sealed at surface, extended to substrate); works limit 2hrs. before/after low tide; calm waves; buffer areas/ relocation/planting*	*Ng*
Activity #s ______ Marine Flora	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Marine Flora	N/A	N/A	N/A	N/A	N/A
e.g. Marine Fauna (coral, invertebrates)	*Sedimentation or other physical/dredging/excavation/chemical/erosion disturbance; loss of habitat/ cover/chemical & biological function*	*loss of nursery/fisheries/ reef/sand production; loss of shoreline protection/biodiversity*	*VH*	*Contain works & contamination source; modified boundary sketch; properly deployed turbidity curtain (70% shade cloth, weighted at bottom, floated/sealed at surface, extended to substrate); works limit 2hrs. before/after low tide; calm waves; relocation/planting*	*Ng*
Activity #s ______ Marine Fauna -	N/A	N/A	N/A	Note: ensure continued mitigation on pre-existing permit for dredging, reclamation, and seawall	N/A
Activity #s ______ Marine Fauna -	N/A	N/A	N/A	N/A	N/A

Resource	Pressure & Impact	Effect	Pre-size	Mitigation Response	Post-size
Environmental resource impacted by the works	Change in this resource due to the works	Consequence of the change in the resource due to the works	Magnitude of the effect with no mitigation	Measure used to mitigate/minimize the harm	Magnitude of the effect with mitigati
e.g. Terrestrial Flora (plants & trees)	*Physical/removal/chemical/ erosion disturbance; loss of*	*loss of agroforestry/ biodiversity/foo*	*H*	*Contain works & contamination source; buffer areas; relocation/planting/revegetation*	*Ng*
Activity #s _all LS_ Terrestrial Flora -important import, major agric. trees	Physical/removal disturbance; loss of habitat/moisture/ cover/shade	loss of biodiversity	H	Contain works & contamination source; ensure *Lukwe*j/Beauty leaf tree at SE by road is undisturbed; acceptable loss of other vegetation	L
Activity #s _all OS_ Terrestrial Flora -shoreline veg.	Physical/removal/ erosion disturbance; loss of habitat/ moisture/cover/shade	loss of shoreline protection/sand	H	Contain works & contamination source; retain coconut palms; revegetation using salt-resilient varieties	L
e.g. Terrestrial Fauna (crabs, birds, domestic animals)	*Physical/removal/chemical disturbance; loss of habitat/ chemical & biological function*	*loss of biodiversity/ food supply*	*M*	*Contain works & contamination source; buffer areas; relocation*	*Ng*
Activity #s ______ Terrestrial Fauna -	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Terrestrial Fauna -	N/A	N/A	N/A	N/A	N/A

e.g. Solid Waste (rubbish, recycling, waste reduction)	*Storage/leachate/disposal/ containment/entanglement disturbance; scavengers; loss of habitat/visual & odor quality*	*loss of biodiversity/ human health/space/ recreation*	*VH*	*Contain waste & contamination source; use of covered bins/fencing; recycling; waste reduction; disposal at approved sites (no burning/rubbish pits); comply w/ RMI EPA solid waste regs*	*Ng*
Activity # _1_ Solid Waste -demolition, vegetation removal	Storage/leachate/disposal/ containment/ disturbance; scavengers; loss of visual & odor	loss of biodiversity/ human health/space	H	open bins/fencing; metal recycling; waste reduction; compost vegetation (minor burning/ no rubbish pits); comply w/ RMI EPA solid waste regs	Ng
Activity #s _2-10_ Solid Waste -construction	Storage/leachate/disposal/ containment/ disturbance; scavengers; loss of visual & odor quality	loss of biodiversity/ human health/space	VH	Contain waste & contamination source; open bins/fencing; metal recycling; waste reduction; on-site disposal (minor burning/ no rubbish pits); comply w/ RMI EPA solid waste regs	L
e.g. Liquid Waste (non-hazardous, recycling, waste reduction)	*Storage/leachate/disposal/ containment disturbance; loss of habitat/visual & odor quality*	*loss of biodiversity/ human health/space*	*VH*	*Contain waste & contamination source; sealed bins & emergency spill kits; record keeping; well-maintained machinery & hoses; recycling; waste reduction; disposal at approved facilities; no leaks/cracks in enclosed septic container/ piping; adequate septic & pump-out; comply w/ RMI EPA liquid waste guidance;*	*Ng*
Activity #s _1,9_ Liquid Waste -demolition, septic	Storage/leachate/disposal/ containment disturbance; loss of habitat/visual & odor quality	loss of biodiversity/ human health/space	VH	sealed bins & emergency spill kits; record keeping; well-maintained machinery & hoses; recycling; waste reduction; no leaks/cracks in enclosed septic container/ piping; adequate septic & pump-out; comply w/ RMI EPA liquid waste guidance;	Ng

Activity #s _2-8,10_ Liquid Waste -construction	Storage/leachate/disposal/ containment disturbance; loss of habitat/visual & odor quality	loss of biodiversity/ human health/space	VH	*Contain waste & contamination source; sealed bins & emergency spill kits; record keeping; well-maintained machinery & hoses; recycling; waste reduction; comply w/ RMI EPA liquid waste guidance;*	Ng
e.g. Hazardous Waste *(solid, liquid)*	*Storage/leachate/disposal/ containment/disturbance;* *severe loss of habitat/visual & odor quality*	*loss of biodiversity/ human health/life*	*VH*	*Emergency contain 100% of waste & contamination source; sealed bins & emergency spill kits & PPE; record keeping; storage at approved facilities [no disposal]; comply w/ RMI EPA hazardous waste regs*	*Ng*
Activity #s ______ Hazardous Waste -	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Hazardous Waste -	N/A	N/A	N/A	N/A	N/A

Resource	Pressure & Impact	Effect	Pre-	Mitigation Response	Post-
Environmental resource impacted by the works	Change in this resource due to the works	Consequence of the change in the resource due to the works	Magnitude of the effect with no mitigation	Measure used to mitigate/minimize the harm	Magnitude of the effect with mitigation
e.g. Drainage & Sedimentation	*Road & surface water drainage disturbance; superstructure damage*	*Loss of public & utility access/storm water drainage*	*M*	*Contain works & contamination source; collaborate w/ MWIU/KAJUR/Local Govt.*	*Ng*
Activity #s _all OS_ Drainage & Sedimentation	Road & surface water drainage disturbance;	Loss of public & utility access/storm water drainage	M	Contain works & contamination source; collaborate w/ MWIU; use best practices	Ng
Activity #s _all LS_ Drainage & Sedimentation	Road & surface water drainage disturbance;	Loss of public & utility access/storm water drainage	M	Contain works & contamination source; collaborate w/ MWIU; use best practices	Ng
e.g. Erosion & Sedimentation	*Shoreline & vegetation disturbance; loss of land*	*Loss of public access/ property/shoreline protection/vegetation buffer/recreation*	*H*	*Contain works & contamination source; modified boundary sketch; geotextile material; buffer areas; proactive planting; cease works during downpours*	*Ng*
Activity #s _all OS_ Erosion & Sedimentation	Shoreline & vegetation disturbance; loss of land	Loss of public access/ property/shoreline protection/vegetation buffer	H	Contain works & contamination source; geotextile material; buffer areas; proactive planting; cease works during downpours	Ng

Activity #s _all LS_ Erosion & Sedimentation	Shoreline & vegetation disturbance; loss of land	Loss of public access/ property/shoreline protection/vegetation buffer	H	Contain works & contamination source; sheet piling on pre-existing permit; cease works during downpours	Ng
e.g. Shoreline Protection	*Shoreline & vegetation disturbance; loss of land*	*Increased risk of flooding; loss of public access/property / vegetation buffer/ recreation*	*VH*	*Contain works & contamination source; modified boundary sketch; small-scale pits; adequate seawall/revetment tie-in & angled boundaries; berm-top barriers; geotextile material; buffer areas; revegetation*	*Ng*
Activity #s ______ Shoreline Protection	N/A	N/A	N/A	Note: ensure continued mitigation on pre-existing permit for dredging, reclamation, and seawall	N/A
Activity #s ______ Shoreline Protection	N/A	N/A	N/A	N/A	N/A
e.g. Neighboring Properties	*Erosion disturbance; increased wave energy from*	*loss of beach/ vegetation/shoreline protection*	*H*	*Contain works & contamination source; buffer areas; ensure adequate seawall/revetment tie-in*	*Ng*
Activity #s ______ Neighboring Properties	N/A	N/A	N/A	Note: ensure continued mitigation on pre-existing permit for dredging, reclamation, and seawall	N/A
Activity #s ______ Neighboring Properties					
e.g. Construction Noise	*Sound related to machinery/power generation/traffic/personnel/building during the works*	*loss of hearing/ concentration/ recreation; marine & terrestrial animal disturbance*	*H*	*Contain works w/ fencing that partially reflects noise; works limit to daytime/weekday hours; use of machinery & generator mufflers; limit use of 2-stroke engines*	*Ng*

Activity #s _all OS_ Construction Noise	Sound related to machinery/ traffic/personnel/building during the works	loss of hearing/ concentration	M	Contain works w/ fencing that partially reflects noise; works limit to daytime/weekday hours; use of mufflers; limit use of 2-stroke engines	Ng
Activity #s _all LS__ Construction Noise	Sound related to machinery/ traffic/personnel/building during the works	loss of hearing/ concentration	M	Contain works w/ fencing that partially reflects noise; works limit to daytime/weekday hours; use of mufflers; limit use of 2-stroke engines	Ng
Resource	Pressure & Impact	Effect	Pre-size	Mitigation Response	Post-size
Environmental resource impacted by	Change in this resource due to the works	Consequence of the change in the	Magnitude of the effect	Measure used to mitigate/minimize the harm	Magnitude of the
e.g. Construction Traffic & Air Quality	*Congestion, black smoke, & dust related to machinery/ trucks/cars/personnel during the works*	*loss of access/ability to breathe/time*	*H*	*Contain works w/ attention to encroachment beyond boundaries; works limit to daytime/weekday hours; use of traffic cones/signage/person directing traffic; well-maintained machinery & generators; limit use of 2-stroke engines*	*Ng*
Activity #s _all OS_ Construction Traffic & Air Quality	Congestion, black smoke, & dust related to machinery/ trucks/cars/personnel during the works	loss of access/ability to breathe/time	H	Contain works; works limit to daytime/weekday hours; use of traffic cones/signage/person directing traffic; well-maintained machinery; limit use of 2-strokes	Ng

Activity #s _all LS_ Construction Traffic & Air Quality	Congestion, black smoke, & dust related to machinery/ trucks/cars/personnel during the works	loss of access/ability to breathe/time	H	Contain works; works limit to daytime/weekday hours; use of traffic cones/signage/person directing traffic; well-maintained machinery; limit use of 2-strokes	Ng
e.g. Public Access	*Physical disturbance [temporary or permanent]*	*loss of food supply/ recreation*	*M*	*Use of buffer areas; installation of stairs within seawall/revetment*	*Ng*
Activity #s ______ Public Access	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Public Access	N/A	N/A	N/A	N/A	N/A
e.g. Public Safety	*Physical/ chemical disturbance*	*loss of human health/life*	*VH*	*Contain works & contamination source; safety signage/fencing surrounding site; consult w/ CHPO on presence of unexploded ordinance*	*Ng*
Activity #s _all OS_ Public Safety	Physical/ chemical disturbance	loss of human health/life	H	Contain works & contamination source; safety signage/fencing surrounding site	*Ng*
Activity #s _all LS__ Public Safety	Physical/ chemical disturbance	loss of human health/life	H	Contain works & contamination source; safety signage/fencing surrounding site	*Ng*
e.g. Worker Safety	*Physical/ chemical disturbance*	*loss of human health/life*	*VH*	*Contain works & contamination source; safety signage/fencing; comply w/ RMI Labor standards & MWIU building code; consult w/ CHPO on presence of unexploded ordinance*	*Ng*
Activity #s _all OS_ Worker Safety	Physical/ chemical disturbance	loss of human health/life	VH	Contain works & contamination source; safety officer on site w/ weekly briefs & daily toolbox meets; safety signage/fencing; comply w/ RMI Labor standards & MWIU building code	Ng

Activity #s _all LS_ Worker Safety	Physical/ chemical disturbance	loss of human health/life	VH	Contain works & contamination source; safety officer on site w/ weekly briefs & daily toolbox meets; safety signage/fencing; comply w/ RMI Labor standards & MWIU building code	Ng
Activity #s ______ Other	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Other	N/A	N/A	N/A	N/A	N/A
Activity #s ______ Other	N/A	N/A	N/A	N/A	N/A

4. Post-Development Operations

Note: There remains significant uncertainty as to the full scope of both the construction (*ie*., earthmoving) and post-development operations of the cold storage facility. The construction determines the scale of the facility, and therefore affects the impact of post-development operations. The draft EmPA (Mar. 7, 2023) made considerable progress on available details, but the applicant/donor has yet to clarify/provide:

- scope and scale of tuna facility (whether only handling, storage, and export or also fish processing and value-added packaging);
- storage, treatment, and/or processing details for any fish waste generated (liquid and solid);
- final design for the main cold storage building;
- type, dimensions, and location of anticipated support buildings;
- number, dimensions, and location of water tanks/catchments and associated piping;
- anticipated freshwater demand for the facility, and therefore the projected back-up municipal water usage (however small);
- number, dimensions, and location of septics and associated piping;
- extent of rooftop solar to be installed, and therefore the projected municipal power usage;
- details on the type and amount of packaging for export *(e.g*., Styrofoam and other plastics)
- scope and scale of dockside loading/unloading (whether by container or other means);
- scope and scale of transport between Delap and Kramer docks (whether container trucks across bridge or not); and
- disaster risk reduction measures/contingency plan for periods of drought and inundation damage from storms;

This section nonetheless attempts to cover these topics based on the information available, qualified where possible at this stage. It may be that some of this information may not be fully available until the applicant produces the Environmental Management Plan (with ToR input from the Marshall Islands EPA), which is recommended by this PEA (and by FAO) to be in place before the Earthmoving Permit is issued.

1. Impacts of Development on the Environment: Describe what the effect of the completed development is on the environment over time (years/decades), and the proposed actions to mitigate this effect (applicant commitment and EPA requirement). For example, a marina has boats that produce wastes; a seawall increases wave energy that causes down-current erosion and fronting beach loss; a less-than-adequate structure is prone to damage during inundation and storms and creates demolition waste that needs to be managed, etc.

Energy and Materials

-Peak energy use may be up to 2 MW of electricity (*pers. comm*., M. Stege, Feb. 24). Information on the amount of rooftop solar to be installed has not been provided. Given that the surface area of the cold storage building (over 10,000m^2) and presumably some roof area available on the associated buildings, approximately half the peak energy demand can be potentially met with maximum solar installation.

-The amount of concrete and rebar required to lay the cold storage building slab is over 8,000m^3. Information on the type and quantity of other materials, including for the refrigeration units, has not been provided.

-It is proposed that 356 shipping containers (12m length) be stacked on site. The total amount of corrugated steel making up the containers is therefore about 90m^3.

-The facility may handle up to 90,000 MT of tuna annually. This is approximately 450 MT per work day, or conservatively works out to about 140 transshipments annually, where the product is unloaded, stored, repackaged, and eventually exported. It is difficult to estimate the amount of fuel needed for this process (*e.g.,* cranes, refrigeration, trucks), without knowing whether containers need to be transported via Delap dock.

WASH and Liquid Waste

-It is also difficult to estimate peak freshwater demand without knowing how much water is consumed in the refrigeration process, and the extent that fish processing may become integrated over time. Service vehicles and equipment may require daily washdown, as do the interior walls and floors of the facility. Earthmoving includes trenching for hook-up to the municipal water supply as well as foundations for water tanks/catchments to be filled from extensive guttering from rooftops on all buildings. Freshwater will be almost entirely provided on-site, with only minor municipal water needed (J. Kramer, *pers. comm*., 2023). There are no plans for reverse osmosis from seawater intakes, although this can be a consideration. The current tuna value chain consumption in Majuro is at about 3% of the municipal water supply (VCA Rep., 2022). Contingencies for periods of drought and damage to water delivery infrastructure (on-site and off-site) from storms need to be factored in, and consideration should be given to desalination via reverse osmosis.

-The wastewater produced by the facility is both seawater and freshwater. Seawater will be pumped in for seawater-flush toilets, with effluent discharged into on-site septic tanks with normal settling/overflow and occasional pump-out for disposal into the municipal waste stream. There will no municipal sewer pipe connection. Waste freshwater depends on the freshwater demand as described above, and may produce varying waste streams. Hazardous liquid waste is not expected, but if any is produced from contact with hydrocarbons it must be contained according to the Marshall Islands EPA guidance/regulations. Non-contaminated runoff from facility and equipment washdown will not be contained, but an expansion into fish processing beyond the current plans for handling, storing, and export will require water in contact with fish waste to be separately treated (and separated from solid fish waste). No information has been provided to date on the likelihood of such processing and the options for liquid waste treatment available, other than an assertion that all fish waste can be treated on-site (J. Kramer, *pers. comm*., 2023).

Solid Waste

-While it has not yet been established that the facility will process tuna for value-added packaging, at a minimum there will be some fish waste even if the product is solely exported in bulk. Any minor fish waste produced (after separation from liquid fish waste) will be handled in a similar manner to how other actors in the Marshall Islands' tuna value chain process waste, by working with the Majuro Atoll Waste Company to promote composting, with the likely addition of on-site waste processing and disposal to handle possible larger volumes in the future. This will include being processed into fish meal and fish oil (J. Kramer, *pers. comm*., 2023).

-Other solid waste such as damaged packaging will be disposed of in accordance with RMI EPA Solid Waste Regulations. Limited burning of wood (*e.g*., broken pallets) may take place, but there will be no garbage pits. Efforts will be made to minimize the use of Styrofoam and to source alternatives to all forms of plastic packaging where they exist.

Transport

-While it is envisioned that there will be ship container off-loading and on-loading at the Kramer Dock, currently the Marshall Islands Govt.-approved site for such activities is Delap Dock. In the unlikely event that this exclusivity continues, the road (although less than 2km distance) and bridge may experience heavy traffic between Delap and Kramer Docks. This would cause stress on road and bridge infrastructure, which may have environmental consequences during potential repair activities as well as constituting an opportunity cost for disaster risk reduction.

-While the amount of fishing in the Marshall Islands waters may not increase, the efficiency of the cold storage facility may attract offloading in the Marshall Islands from vessels that currently offload elsewhere, and thus increase vessel traffic in Majuro lagoon. This will create a proportionate increase in the demand for both marine and land-based services to support the increased vessel presence, notably across the range of restocking (*e.g.,* food, water, fuel) normally carried out while in port.

2. Impacts of Development on Climate Change: Describe what the effect of the completed development is on the efforts of the Marshall Islands to mitigate and adapt to climate change, and transition to climate proofing all infrastructure (applicant commitment and EPA requirement). Does the development help or hurt these efforts? For example, facilities that use non-renewable power

sources increase the Marshall Islands' contribution to greenhouse gas emissions, a non-elevated structure does not conform to projected conditions of survival during sea-level rise, and seawalls and other hard fortifications go against guidance that promotes nature-based solutions. Does the development only address immediate/short-sighted concerns or is it consistent with the Marshall Islands' Adaptation Plan?

Mitigation

-With respect to climate change mitigation from the emissions operation of buildings, refrigeration, and infrastructure, the roof-top solar on at least the main cold storage building will complement its municipal power hook-up. While current refrigeration onboard fishing vessels may not be reduced at sea, transfer to land-based cold storage may decrease the emissions produced by moored vessels awaiting export, and increase efficiency. In this respect, significant installation of roof-top solar may reduce the Marshall Islands' total emissions. The power draw for the facility will nonetheless be significant to support the refrigeration needed.

-With respect to climate change mitigation from the emissions operation of vehicles, loaders, cranes, and other support equipment, there is no use of alternative fuels planned, apart from the possible exception of some coconut biofuel use in smaller vehicles.

Adaptation

-With respect to climate change adaptation to sea-level rise (SLR) and wave inundation, the bottom of the refrigeration units is to be 1200mm above an 900mm slab (100mm for ventilation pipes) to facilitate loading access. Therefore, the cold storage where the tuna is to be housed is 2.1m above the current grade on site. The distance to the high-water mark from any construction is 60m on the lagoon side, and 30m on the ocean side. This elevation is therefore more than twice the projected SLR by 2100 under moderate global emissions scenarios. However, it is recognized that climate proofing per the Marshall Islands' Adaptation Plan should incorporate flow-through for inundation on the bottom floor (*e.g.*, MIMRA building), which is not the case for the main cold storage building. Although this feature may be added via either 115m long culverts through the 900mm slab or a re-design of the first floor. Else the development only partially serves to promote the Marshall Islands' efforts for climate change adaptation.

Hazard Background

-Historically, drought and tropical storms (cyclonic, several days with heavy rainfall and high winds) tend to occur during periods of El Niño and extratropical wave inundation (long-distance swells from far-off areas) largely occur during La Niña Niña or neutral phases of the ENSO (El Niño Southern Oscillation). Predictable cyclonic generation and storm paths in the region and predominant winds from the NE and South allowed disaster management authorities to plan for preparation, response, relief, and recovery. But the recent decade with longer term periods of drought, wind reversals during El Niño, slow-moving and higher category storms with heavier rainfall, and a general intensification of magnitude and frequency of both slow and rapid-onset events has demonstrated the urgency of adaptation via climate proofing of both new and existing buildings and infrastructure.

-Hazard planning is therefore particularly important in areas of reclaimed land, where adjacent reefs and subterrain inland of the high-water mark do not provide adequate shoreline protection

services. Moreover, reefs fronting the lagoon side of the developed areas of Delap-Uliga-Djarrit and Rairok on Long Island are in poor ecological health, without the necessary ecological function to serve in any adaption capacity. This is largely due to pollution, sea-surface temperature increase, and dredging – with effects that combine to reduce coral cover and promote phase shifts to algal reefs.
-The lagoon shoreline of Delap and Rairok out to the airport, including where Kramer Dock is located, is exposed to a significant fetch from across the water from the predominant NE wind direction, and thus experience regular inundation and erosion. The industrial area of Kramer Dock is comparatively overexposed from the perspective of having deep, dredged areas along its shoreline that magnify the incoming swells. However, it is reasonably fortified with ongoing works to build seawalls underpinned with sheet piling to mitigate against collapse of the reclaimed land on which it is built.

3. Impacts of Climate Change on the Development: Describe what are the adverse effects of increased climate change on the completed development, known as a 'reverse environmental assessment' (applicant commitment and EPA requirement). How probable is it that climate change will render the development obsolete or damaged beyond repair (years/decades)? Has the applicant factored in sea-level rise, increased storm frequency & intensity, reduced coral reef biodiversity & coastal fisheries, reduced fresh water supply, salt intrusion into island water lenses, and limited agriculture due to shorter/drier growing seasons? The seawall of today becomes the breakwater of the future; another stranded asset.

-Despite overlaps in context and background, the previous section included impacts on efforts to adapt to climate change, while this section is more focused on insufficient, inadequate, or *mal* adaptation.
-With adequate elevation and climate proofing, the facility itself is unlikely to sustain direct physical damage from storms and SLR, but local services and infrastructure (*e.g*., vessels, power, water, and sewer) necessary for its operation are likely to experience disruption from climate change impacts. The area of Rairok needs updated SLR and climate impact projections to be able to fine-tune predictions for inundation during variable weather and tide scenarios. Elevation and bathymetry data is available for Majuro from the Marshall Islands Lands and Survey Office (from 2016 DEM-Digital Elevation Model) work by USGS, and from 2019 LIDAR-Light Detection and Ranging work by SPC). In the past, Dr. Chip Fletcher from University of Hawai'i modeled numerous SLR scenarios under the different RCPs (Representative Concentration Pathways) for Delap-Uliga-Djarrit, which need to be updated. The grade of the grounds around the facility is currently at 1m above mean sea level during calm conditions. During a strong La Niña, water piles up in the central and western Pacific, reducing this to 70cm. Factoring in extremes during king tides, this buffer further reduces to 40cm at high tide. Combining with significant storm or swell events (during a strong La Niña at king high tide), the buffer is 0 as the grade is at sea level. This has been documented by flooding events, although more pronounced in non-fortified areas. Add SLR to the mix, and the flooding is conservatively another 50cm by 2050. This is more than half the elevation of the 90cm level at the bottom of the refrigeration units. The other half will most certainly be flooded before 2100, and possibly even by 2050 if less conservative RCP futures are experienced. Thus the adequacy of the

facility elevation depends on optimism that the world will not experience runaway emissions, or carry on business as usual.
-Vessels may not be able to fish or berth due to adverse conditions; and increased inundations may damage older and less-elevated utility infrastructure off-site.
-Tuna migration patterns across the region may change with warming sea temperatures, stock projections not meeting minimum volumes for export. At best, such changes may require added fishing effort (time, distance, and cost). At worst, the facility becomes a stranded asset.
-In the context of disaster risk reduction, the facility can also serve as an emergency shelter (without refrigeration) or as food storage for local vendors and even as a temporary morgue (with refrigeration). In those instances, refrigeration for tuna storage will either not be available, or limited. Moreover, water shortages during drought not mitigated with back-up catchment storage or desalination capacity can significantly limit the ability to process tuna (if it becomes part of the development plan).

<u>Note</u>: Before recommending relevant concerns for the EMP, the different possible options for the facility need to be stated:

A. Cold storage building and associated water, power, and septic infrastructure without support buildings, limited to handling, storage, and export (no tuna processing for value-added export). This option also assumes that fishing vessels will be unloaded and packed into containers to be trucked to Delap Dock, but that the Kramer Dock will not be designated as a container loading facility.
B. Option A, but with designation as a container loading facility and no transport needed to Delap Dock.
C. Option A + support buildings to be a full-service tuna processing facility for value-added export.
D. Option B + support buildings to a full-service tuna processing facility for value-added export.

Relevant concerns for the EMP that require mitigation planning can be summarized:

• Construction (including demolition) Section (re-stated from PEA table)

<u>All Options A-D</u>
-status of dredging, reclamation, sheet piling, and seawall
-freshwater quality and quantity
-salt water quality (*ie.*, salt water flush intake)
-terrestrial flora (retain *Lukwej*/Beauty Leaf trees)
-solid and liquid waste
-drainage and sedimentation (roads)
-erosion and sedimentation (shoreline)
-noise, traffic, and air quality
-public and worker safety

• Post-Development Operations Section

<u>All Options A-D</u>
-extent of roof-top solar and leftover municipal power demand

-extent of on-site water tanks/catchments/reverse osmosis and leftover municipal water demand

-WASH (Water, Sanitation, and Hygiene)

-terrestrial flora (retain *Lukwej*/Beauty Leaf trees)

-solid and liquid waste

-noise, traffic, and air quality

-public and worker safety

-disaster risk reduction and disaster management contingencies (*e.g.*, drought, storms, and inundation)

Options A and C

-wear and tear on bridge and road due to container traffic

Option C and D

-solid and liquid fish waste processing/disposal/conversion to fish meal/oil

The list of concerns can be used by the RMI EPA in their process of defining the ToR for the EMP.

4. Recommendations

[x] Further information required before an EIA/No EIA recommendation can be made, including:

- [ ] Terrestrial Flora & Fauna Assessment beyond site visit done in this PEA.
- [ ] Marine Flora & Fauna Assessment beyond Recon done in this PEA (Snorkeling/Diving).
- [x] More detailed project design information needed from the Applicant, that was not identified before conducting the PEA.
- [ ] Informal public consultation on the extent of community support for the project.
- [x] Applicant needs to submit Environmental Management Plan (EMP) for EPA approval, and EPA needs to first provide guidance/ToR for its development.
- [ ] Other: ____________________

[ ] EIA Required

- [ ] Formal (Legislated) public consultation on the extent of community support for the project.
- [ ] Earthmoving/construction impacts cannot be addressed in this PEA, with several post-mitigation magnitudes above negligible (irreversible harm).
- [ ] Post-development operations impacts cannot be addressed in this PEA, with respect to climate change implications.
- [ ] Earthmoving/construction/post-development operations constitute major strategic/ program shifts in development for the RMI and cannot be addressed in this PEA.
- [ ] Other: ____________________

☐ EIA not required but the following conditions should be attached to approval:

☐ Follow permitting conditions (from EmPA and PEA) to be outlined with permit.

☐ Follow recommendations outlined in the Terrestrial Flora & Fauna Assessment.

☐ Follow recommendations outlined in the Marine Flora & Fauna Assessment.

☐ Follow management conditions outlined in the EMP.

☐ PEA is sufficient to recommend that the project not be allowed to proceed. The proponent has the opportunity to re-apply and submit a revised earthmoving application for consideration.

Rationale: ____

_Karl Fellenius____________ ____________________ ___________________

Assessor Name Assessor Signature Date Signed

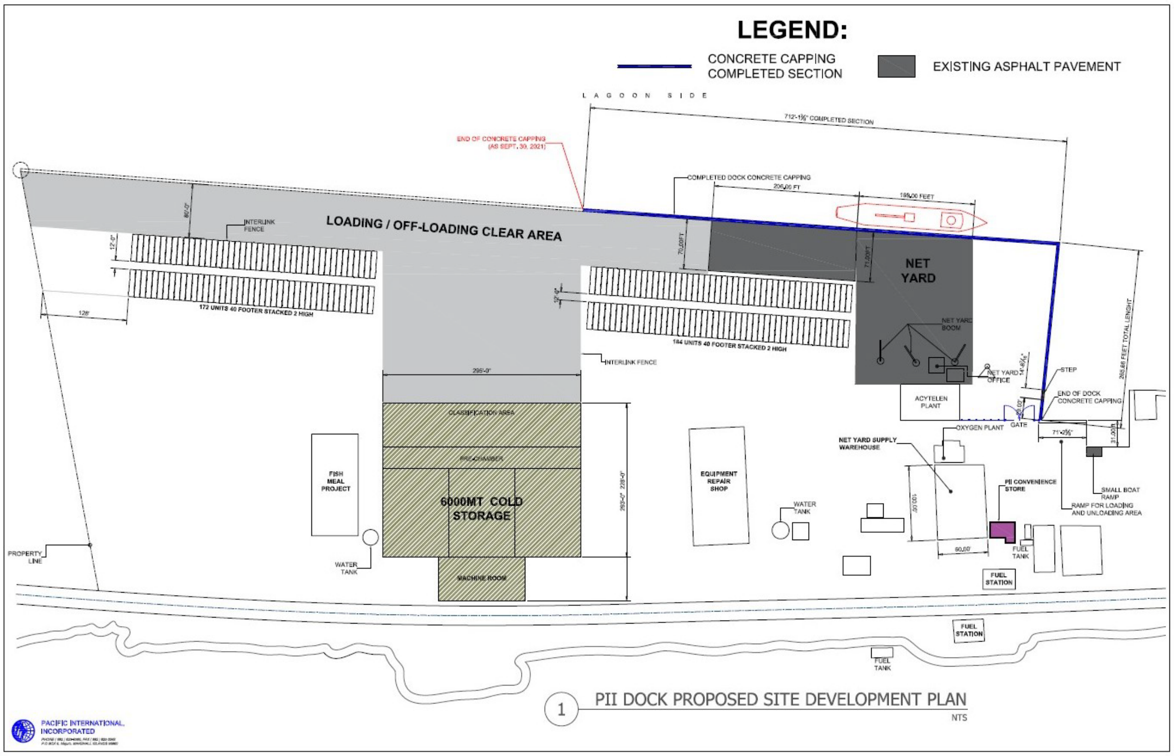
_Melvin Kilma____________ ____________________ ___________________

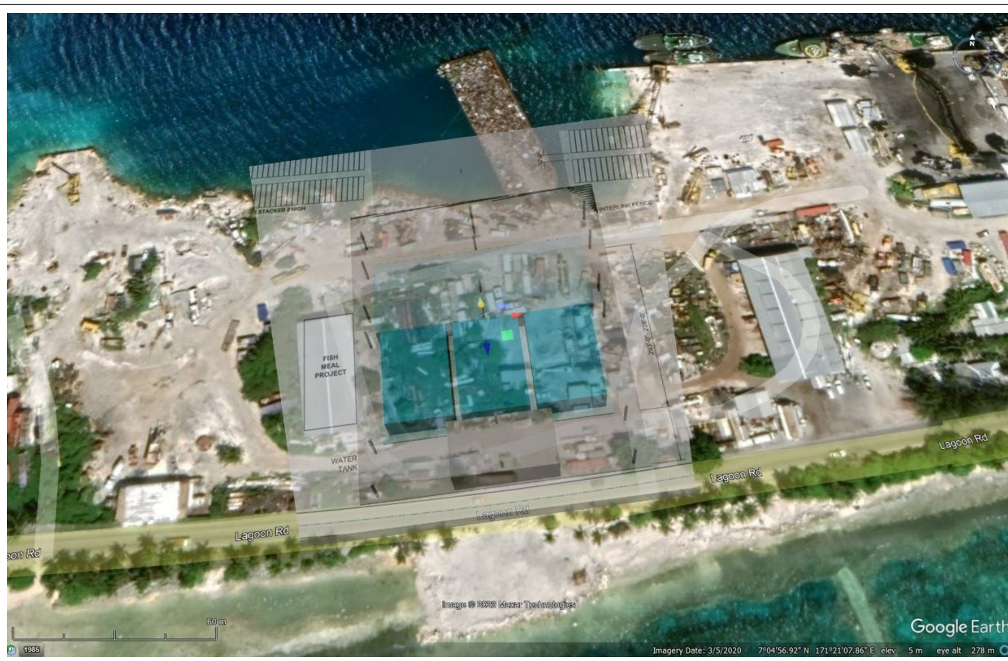
Division Chief Name Assessor Signature Date Signed

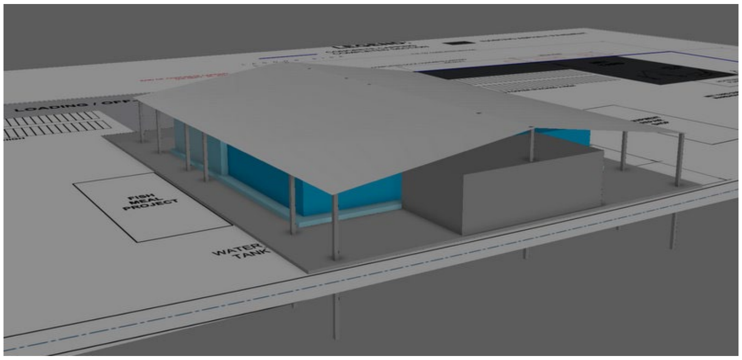
_Moriana Phillip___________ ____________________ ___________________

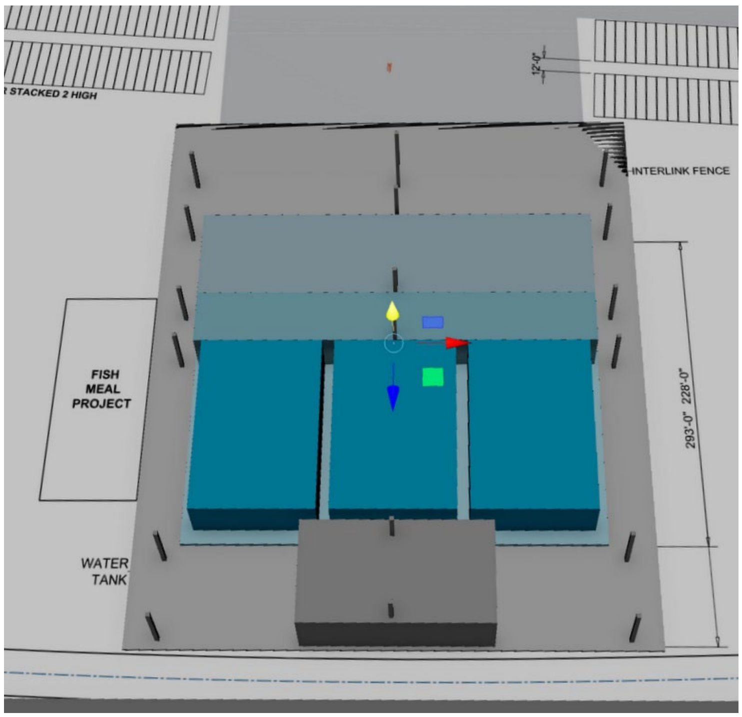
General Manager Name General Manager Signature Date Signed

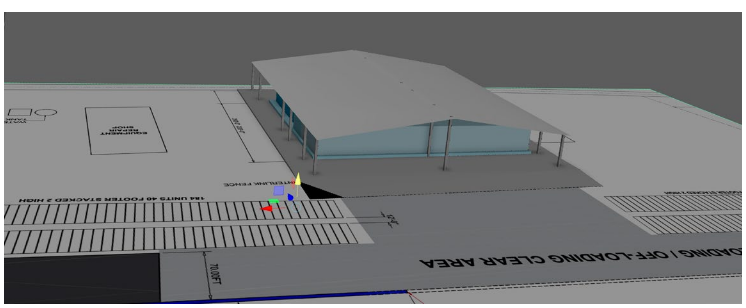
For any modification to the applicant's boundary conditions, provide a drawing or other layout plan with dimensions, a scale, and labels to explain the proposed/numbered activities and their locations with respect to features such as the high-water mark and road. For projects that require the use of a turbidity curtain, show any modified deployment location and indicate whether/the order it is re-deployed in stages to follow dredging progression. Superimposing the drawing on a Google Earth image is recommended. Such modification must be accepted by both the Division Chief and the applicant before seeking GM approval.


LEGEND:
CONCRETE CAPPING COMPLETED SECTION
EXISTING ASPHALT PAVEMENT
LAGOON SIDE
LOADING / OFF-LOADING CLEAR AREA
NET YARD
172 UNITS 40 FOOTER STACKED 2 HIGH
184 UNITS 40 FOOTER STACKED 2 HIGH
INTERLINK FENCE
6000MT COLD STORAGE
MACHINE ROOM
FISH MEAL PROJECT
EQUIPMENT REPAIR SHOP
WATER TANK
PROPERTY LINE
ACYTELEN PLANT
OXYGEN PLANT
NET YARD SUPPLY WAREHOUSE
PII CONVENIENCE STORE
FUEL TANK
FUEL STATION
SMALL BOAT RAMP
RAMP FOR LOADING AND UNLOADING AREA
END OF DOCK CONCRETE CAPPING
1 PII DOCK PROPOSED SITE DEVELOPMENT PLAN
NTS
PACIFIC INTERNATIONAL, INCORPORATED


FISH MEAL PROJECT
WATER TANK
Lagoon Rd
Google Earth
Imagery Date: 3/5/2020


FISH
MEAL
PROJECT
WATER
TANK


STACKED 2 HIGH
12'-0"
INTERLINK FENCE
FISH
MEAL
PROJECT
293'-0"
228'-0"
WATER
TANK



Additional Project Information

The PEA is part of project funding under the FISH4ACP value-chain program, implemented by FAO via a feasibility study on constructing and operating a cold storage facility in Majuro for landing, sorting, and storing commercial tuna catches prior to export.

The only conceptual and preliminary design available to date is for the main cold storage building on the lagoon side. However, it is expected that up to another 10 smaller facilities and associated infrastructure are to be situated at the site, including some on the ocean side.

The main cold storage building is approximately 115m (N-S) x 90m (E-W), and houses 3 elevated refrigeration units (each approximately 50m x 30m), a classification area, a pre-chamber, and a machine room. The slab will have ventilation pipes to account for condensation, and a continuous/floating perimeter foundation will be used instead of footings since the facility is on reclaimed land requiring loads to be spread out. The bottom of the refrigeration units is to be 1200mm above an 900mm slab (ventilation pipes add 100mm) to facilitate loading access. Therefore, the cold storage where the tuna is to be housed is 2.1m above the current grade on site. The distance to the high-water mark from any construction is 60m on the lagoon side, and 30m on the ocean side.

The overlay of the conceptual drawing of the cold storage facility onto the Kramer Dock suggests that the north boundary of the facility will sit approximately at the current shoreline, with the container stacks located on land to be reclaimed (and therefore with the 60m buffer to the high-water mark). Reclamation to this extent is an already permitted activity along with the continuation of the east sheet piling/concrete seawall and dredging to the north. PII is renewing their historical permit with the RMI EPA to reflect their active works, so the tuna cold storage project remains a land-based PEA instead of involving marine dredging and reclamation and a significantly different scope. Proper mitigation is being followed, including an upgraded/anchored turbidity curtain at the West boundary.

Annually, there may be up to 90,000 metric tonnes of tuna going through the 600 metric tonne storage facility. All tuna will be offloaded at Kramer Dock but questions remain whether containers will be loaded (and thus efforts to ensure sufficient depth for vessels), or at least partially trucked in from the current the Marshall Islands-Govt. approved stevedoring at Delap Dock, with transport over the bridge. This contributes to the

Smaller Scale View of Kramer Dock and Surroundings [provided by PII]

This report presents the results of the tuna cold store feasibility study conducted in the purse seine tuna fishery value chain in the Marshall Islands from 2021-2022 by the value chain development programme FISH4ACP.

FISH4ACP is an initiative of the Organisation of African, Caribbean and Pacific States (OACPS) aimed at making fisheries and aquaculture value chains in twelve OACPS member countries more sustainable. It contributes to food and nutrition security, economic prosperity and job creation by ensuring the economic, social and environmental sustainability of fisheries and aquaculture in Africa, the Caribbean and the Pacific.

FISH4ACP is implemented by FAO with funding from the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ).

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DEUTSCHE ZUSAMMENARBEIT

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