CHAPTER 247

WAVE AGITATION CRITERIA FOR FISHING HARBOURS IN ATLANTIC CANADA

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ABSTRACT: The existing criteria for defining allowable levels of wave agitation in Canadian harbours are outlined in the Guidelines of Harbour Accommodation (Fisheries and Oceans). These criteria were developed based on a previous study which concentrated primarily on recreational harbours. However, it was realized that fishing vessels, when berthed or moored, may be able to tolerate a greater degree of wave agitation than pleasure craft because of the different characteristics and functions of the two types of vessels. Furthermore, fishermen tend to have more liberal tolerance limits to wave agitation than pleasure craft owners, and have more rugged craft. To develop new allowable wave agitation criteria for commercial fishing harbours in Atlantic Canada, a field measurement programme was conducted in selected harbours. The objective was to determine the threshold values at which the wave climate at both the service/offloading area and mooring area creates either dangerous, difficult or unacceptable working conditions. This was determined to be the point at which operations must cease or the vessel had to be removed to a more protected area. Wave measurement gauges were installed at two locations within two study harbours, and a wave rider buoy was used to measure nearshore waves for each harbour site. A procedure was also developed whereby daily field observations were taken and recorded by the harbour master. Particular emphasis was given to the wave climate events which rendered the facilities less than adequate, unsafe or unusable. By correlating the harbour masters field observations with the measured wave data, the threshold values for unacceptable wave agitation were determined, and new wave agitation criteria for fishing harbours recommended.

INTRODUCTION

The criteria (and practice) for defining allowable levels of wave agitation in Canadian harbours prior to 1991 were developed by the Small Craft Harbours Directorate (SCHD), and are

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outlined in the Guidelines of Harbour Accommodation by Fisheries and Oceans (F&O, 1985). These criteria were applicable to harbours which fall under the administration of the SCHD and it was customary to follow these criteria for all work undertaken on behalf of the SCHD.

This study (Atria, 1991) was developed with the objective to revise the acceptable wave agitation criteria that have been used by engineers when engaging in the planning and design of fishing harbours. The criteria (F&O, 1985) which specify the agitation requirements within fishing harbours were developed based on a previous study (NHCL, 1980). The 1980 study to determine acceptable wave climates in small craft harbours concentrated primarily on recreational harbours. It was realized that fishing vessels, when berthed or moored, may accept greater degrees of wave activity than pleasure crafts because of the different characteristics and functions of the two types of vessels. Furthermore, fishermen tend to have more liberal tolerance limits to wave agitation than pleasure craft owners. Also, as a rule fishermen have more rugged craft. A reduction in wave agitation criteria could yield optimized protective structures and hence significant savings in capital costs.

The purpose of the present study was to develop new allowable wave agitation criteria for fishing harbours. The scope of the work consisted of: 1) reviewing existing wave agitation criteria for fishing harbours within Canada and abroad; 2) undertaking a field measurement programme in conjunction with the Marine Environment Data Service (MEDS) at two fishing harbours with the aim of establishing the point at which unacceptable wave conditions occur; and 3) recommending new guidelines of accommodation specifically for allowable wave agitation in fishing harbours.

EXISTING WAVE AGITATION CRITERIA

The existing wave agitation criteria were obtained by means of a literature review and a questionnaire survey. The questionnaire was sent to various organizations in Canada and foreign countries such as U.S.A., England, Japan, Denmark, Holland and others. Each organization was asked for information regarding guidelines for fishing harbour design in their country as well as the description of the fishing fleet for which their guidelines apply.

Canada: The Guidelines of Harbour Accommodation, developed by the SCHD (F&O, 1985), outline the criteria (and practice) for defining allowable levels of wave agitation in Canadian harbours. These criteria were based on NHCL (1980). Since this study was restricted to recreational craft, directly applying the results of their findings to fishing harbours likely resulted in conservative allowable agitation levels for fishing harbours. Therefore the criteria that were developed and proposed for all harbours (including fishing harbours) are more stringent when applied to fishing harbours than if the study considered fishing harbours alone. It is customary at Public Works Canada and with consulting engineers when undertaking SCHD projects to design the facility such that the agitation levels within the harbour meet the requirements of the guidelines.

The recommended allowable wave agitation criteria (Tables 1 and 2) were determined by classifying harbours by vessel-metres usage. Class A harbour is defined as over 800 vessel-metres, Class B as between 300 and 900 vessel-metres, and Class C between 0 and 400 vessel-metres. The existing guidelines specify that for Class A, B and C harbours, the hours of significant waves which exceed 0.25 m in height at the service/offloading (i.e. berthing) area cannot be greater than 0.17%, 0.87% and 1.74% of the time respectively. For a 6 month season, these % yield 0.3, 1.6 and 3.2 days (respectively) of wave activity in excess of 0.25 m.

Previous to the NHCL study, the widely accepted rule of practice for the design of wave protection for small craft harbours was that the wave height within the harbour should not exceed 0.3 m (1 ft). Of course, if one waits long enough, a storm will occur and will create waves in excess of this limit. Therefore, wave protection is a function not only of a given acceptable value, but also the probability of occurrence (or exceedance) of the value. The NHCL study examined this "one foot" rule and the many variables affecting wave agitation in marinas, and made recommendations towards an improved set of criteria to define acceptability of wave climates within small craft harbours.

Table 1 Allowable Maximum Significant Wave Height (from F&O, 1985)

Location	All Recreational Boats Fishing Boats < 15 m	Fishing Boats > 15 m
Within Harbour Entrance	1.00 m	1.00 m
Mooring Basin	0.50 m	1.00 m
Berthing Area	0.25 m	0.50 m

Table 2 Classification of Harbours (from F&O, 1985)

Class of Harbour	Percentage of Time when the Wave Height Criteria May Be Exceeded
A	0.17
B	0.87
C	1.74
D	No Limit

In general, their findings revealed that there has been remarkably little research work performed or reported in the literature with respect to wave agitation criteria for small craft harbours or marinas and on response of moored small craft to waves. However, the available literature related to the general subject of marina design, all made reference to wave criteria which came reasonably close to specifying a 0.3 m significant wave height.

United States of America: The ASCE Task Committee on Small Craft Harbours (1969) published a manual on small craft harbours and they recommended simply "in general, wave heights in the mooring basin should be reduced to a maximum of approximately 0.5 ft (0.15 m) to 1 ft (0.3 m)". These criteria were defined with reference to sport and pleasure craft. They stated that: "harbours for commercial fishing boats may be considered a special type of installation. This is due largely to the type of usage, the characteristics and habits of commercial fishermen, and equipment requirements. Usually utility supersedes appearance, because a fishing boat is a work boat and the operator's work in port is essentially preparation for the next trip".

United Kingdom: In England, guidance for wave agitation in harbours is available in the British Standard Code BS6349 (Part 1, 1984). The acceptable wave conditions for moored boats in fishing harbours are given as follows: "since fishing craft are normally larger and more strongly built than pleasure craft the maximum wave height considered as acceptable for boats up to 30 m in length is 0.8 m. Typically, this makes the maximum acceptable significant wave height 0.4 m. As in the case of pleasure craft, inner harbours or basins are frequently provided for accommodating fishing boats safely."

Japan: Japanese fishery ports are administered by the Ministry of Agriculture and Fishery. This Ministry's report "Guide to Planning of Fishery Ports" outlined the range of wave heights available for mooring and water area facilities (Table 3). The wave heights for mooring and water area facilities varies between 0.3 m to 1.2 m (maximum significant). It also stated that the probability of exceedance of these wave heights was not determined. In general, it recommended that ports should be constructed such that the probability of wave heights less than the permitted level becomes more than 97.5% in a year.

Previous to this criteria, the Overseas Coastal Area Development Institute of Japan (1980) recommended that wave agitation was addressed as basin calmness. It stated that a basin in front of a pier (i.e. service/offloading facility) should be calm to allow mooring for 90 to 95 % or more days per year (or each season, when the seasonal variation of calmness is extreme). Calmness was defined as significant wave heights being less than the defined critical wave height. The critical significant wave height for cargo handling in a basin in front of berthing facilities was defined as H_s = 0.3 m for small craft harbours and H_s = 0.5 m to 0.7 m for other craft. It was noted that these criteria may not apply when the frequency of mooring is low such as would be the case with fishing harbours during the fishing season. However, more work on wave agitation in fishing harbours is presently underway in the National Research Institute of Fisheries Engineering (these new publications are in Japanese).

Table 3 Maximum Significant Wave Height for Mooring and Water Area Facilities

Water Depth in Anchorage Area	Less than 3 m	More than 3 m
1. anchoring and mooring in a port is possible	0.60 m	0.70 m
2. water way is available	0.90 m	1.20 m
3. loading and unloading is possible	0.30 m	0.40 m
4. quay for rest is available	0.40 m	0.50 m

Source: "Guide to Planning of Fishery Ports, report by the Ministry of Agriculture and Fishery of Japan.

Nordic Countries: The Nordic Council (1986) published a research report which established criteria for acceptable ship movements in harbours. When considering wave agitation, they found that loading / unloading methods, pattern of the vessel, mooring and fender system, and the ability of the vessel to escape the harbour during a storm, were important factors.

For fishing vessels, the type of loading / unloading method used was of concern. When unloading trash fish they considered the elevator crane. With this method problems arise due to the size of the hatch. Small movements can cause damage to both the ship and the crane. Vertical ship movements can also cause damage to the ship bottom and to the crane. Another problem arises when the ship collides with the fenders causing fish to slide within the hold, causing danger to people within the hold.

Safe mooring conditions was another topic considered in the Nordic Council (1986) report.

Acceptable mooring conditions were considered to be where no damage occurred to the ship or to the quay. Also, they outlined for taut mooring of fishing vessels different values than the ones given in Table 4. Thus, criteria for safe mooring conditions at berth are given in Table 5. In determining the final criteria for vessel movement when moored at berth, it was assumed that she was well moored and that the quay was well equipped with fenders.

Other Countries: No official guidelines were available from other countries contacted by questionnaires. Some answers mentioned "empirical, often subjective rules" and most european countries quoted the Nordic Council (1986) study. In Holland, no specific guidance on wave agitation for fishing harbours were obtained. Reference was made to the Nordic Council (1986) study. Vlemmix et al. (1987) set out criteria for bulk carriers and outlined the limiting deep water wave heights. In Spain, the only available document on fishing harbours dates back to the 1960's. Marine Trust Ltd. of Israel follows in house rules as criteria for wave agitation. A significant wave height of 80 cm may not be exceeded for more than two days per year. Their experience comes from harbours for small fishing vessels with few trawlers. Other references related to the design of Small Craft harbours using physical models may be found in literature, for example Rosen and Kit (1984) which report on limiting criteria regarding maximum allowable values of vessel movements and fender forces.

In general it appears that the F&O (1985) guidelines may be considered too stringent. It has the lowest acceptable wave height and the lowest frequency of occurrence. This is understandable since the values were determined from a study for recreational craft and then adapted to fishing vessels.

In the NHCL (1980) study, from which the SCHD guidelines were developed, much emphasis was placed on the one foot (0.3 m) criterion since it is widely accepted by most authorities. Although it provides satisfactory results in marinas, it neglects the fact that fishing vessels unlike recreational craft can tolerate more agitation. They do point out however, that it is important to consider the wave direction, as beam seas are more distressing than head seas. They also point out that boat response depends greatly on the wave period relative to the boat length.

In the Nordic Council (1986) report, they agree with the F&O (1985) guidelines on the wave height criteria for small vessels. They present their conclusions for larger fishing vessels (25 m to 60 m long) with respect to method of loading/unloading, and ship movements. This data are the result of an investigation on 11 harbours. The Nordic report gives extensive information on acceptable movements for large fishing vessels, but does not provide as much information for smaller fishing vessels.

It is difficult to compare wave height criteria since each report bases its findings on different criteria. F&O (1985) presented its guidelines for frequency of occurrence based on vessel-metres usage. The study done by NHCL (1980) referred to significant wave height with respect to direction and period, as did the Vlemmix et al. (1987) study. Japanese criteria was based on the depth of the harbour. In the case of large fishing vessels the criteria were also presented as a function of ship movements.

WAVE AGITATION STUDY

To develop new allowable wave agitation criteria for commercial fishing harbour, a field measurement programme, managed by Atria and executed by MEDS, was conducted to determine (in the field) the threshold values at which the wave climate at the service/offloading area and mooring area created either difficult, dangerous or unacceptable working conditions.

Wave measurement gauges were installed at two locations within two study harbours. Also, a wave rider buoy was used to measure nearshore waves for each harbour site. Wave data were collected during two fishing seasons to ensure that the majority of extreme wave events (events of unacceptable wave agitation) were well defined.

A procedure was developed and established by Atria and the local harbour masters by which daily field observations were taken and recorded by the harbour master. Particular emphasis was given to the wave climate events which rendered the facilities less than adequate, unsafe or unusable. By correlating the harbour masters field observations with the measured wave data inside the harbour, the threshold values for unacceptable wave agitation were determined.

A synthesized wave climate was developed for the study sites using a parametric wave hindcast model (Atria, 1991). First, waves were hindcasted for the wave measurement period and were calibrated with measured wave data obtained from the offshore wave riders. Subsequently, 20 years of hindcast waves were produced at each fishing harbour and analyzed to define a magnitude-duration-frequency relationship, which was assumed to be representative of the wave climate for the study harbours. By correlating the magnitude of unacceptable wave agitation levels determined from the field programme with the 20 year hindcast, the allowable duration and frequency of unacceptable wave agitation levels were obtained.

Table 4 Criteria for Fishing Vessel Movements during Working Conditions
(Nordic Council, 1986)

Type of Vessel	Surge (m)	Sway (m)	Yaw (°)	Heave (m)	Pitch (°)	Roll (°)
Lift on/Lift off	1.0-1.5	1.0-1.5	3.5	0.4-0.6	3	3-5
Elevator crane	0.15	0.15				
Suction pump	2.0-3.0	1.0-2.0				

Note: The movements are maximum peak-peak. Frequency of occurrence of these movements should be less than is 1 week per year (2 % of the time).

Table 5 Criteria for Fishing Vessel Movements Moored at Berth
(Nordic Council, 1986)

Type of Vessel	Surge (m)	Sway (m)	Yaw (°)	Heave (m)	Pitch (°)	Roll (°)
Fishing Vessel (25 m to 60 m length)	1.2-1.5	1.0-2.0	6	0.6-1.0	4	8

Note: The movements are peak-peak values. For the berth to be acceptable, the frequency of the movements should be less than 3 h/year.

Wave Data Acquisition Programme: The field measurement programme was initiated in December 1989 with the installation of the wave gauges and wave riders at their designated locations in Sandford and Stoney Island harbours, in Nova Scotia, Atlantic Canada. The locations of the inner and outer gauges for each harbour (Figure 1), were designed to record wave agitation data at the service/offloading area and at the harbour entrance respectively. The acquisition of data began in January 1990.

The harbour master field observations covered two field measurement seasons, the first period from December 1989 to end of May 1990 and the second season period from October 1990 to end of January 1990 for both locations. The harbour masters were responsible to visually record wind, wave and harbour conditions on a daily basis. The harbour conditions that were of interest for the present study were those events that could not be tolerated by the fishermen at the service/offloading wharf (i.e. unacceptable harbour conditions) and those events when the wave conditions were severe, but the harbour conditions could be tolerated (i.e. acceptable harbour conditions). The unacceptable conditions provide an indication of the lower bound of wave agitation that is unacceptable, while the acceptable conditions provide the upper bound of wave agitation that is tolerable. Summaries were compiled from the harbour masters field notebooks by condensing the information into categories of weather, waves, and harbour conditions recorded on each day.

The magnitude of the threshold wave height for unacceptable wave agitation at the service/offloading area was determined by simply identifying the measured wave height at the inner wave gauge for each unacceptable event as observed by the harbour master. This process was followed for both harbours. A sample time series plot for Stoney Island was shown in Figure 2 where the occurrences of unacceptable wave conditions were shown as a solid dot at the time of occurrence. Visual inspection of this plot shows a good coherency of measured (by the wave riders) and observed wave data (by the harbour masters) for the unacceptable events.

Similarly, acceptable harbour condition occurrences were also indicated on this time series plot as hollow dots. It is interesting to note that for these dates of acceptable (but severe) conditions, the inner gauge at Stoney Island showed a maximum value of 0.39 m and a minimum value of 0.15 m. This indicated that the harbour condition became unacceptable when the significant wave height exceeded 0.4 m.

Wave Hindcast: A 20 year wave hindcast was conducted to simulate the wave climate for each study harbour at the location of the wave riders. A parametric hindcast model based on the SMB equations (Atria, 1991) was used. The hindcast analysis used wind data from Yarmouth, N. S. as primary input to the model. The model was calibrated to the measured wave data at each wave rider, and subsequently, the long term hindcast was conducted for the 20 year data set using the calibration factors determined from the calibration process.

For both harbours, the hindcast model was calibrated by comparing the MEDS wave data measured at the wave riders with the hindcast waves using Yarmouth winds. In the calibration procedure, the original (smoothed) wind data were first used to hindcast waves in 8 and 16 point sectors. The initial hindcast used the original (unfactored) Yarmouth wind data and resulted in the hindcast waves being generally smaller than the measured values. The hindcast waves were then calibrated with the measured MEDS data by adjusting the wind scale factors until a reasonable match was achieved. Procedures to modify the (Yarmouth) wind data using overwater/overland speed ratios were applied and were presented in Atria (1991).

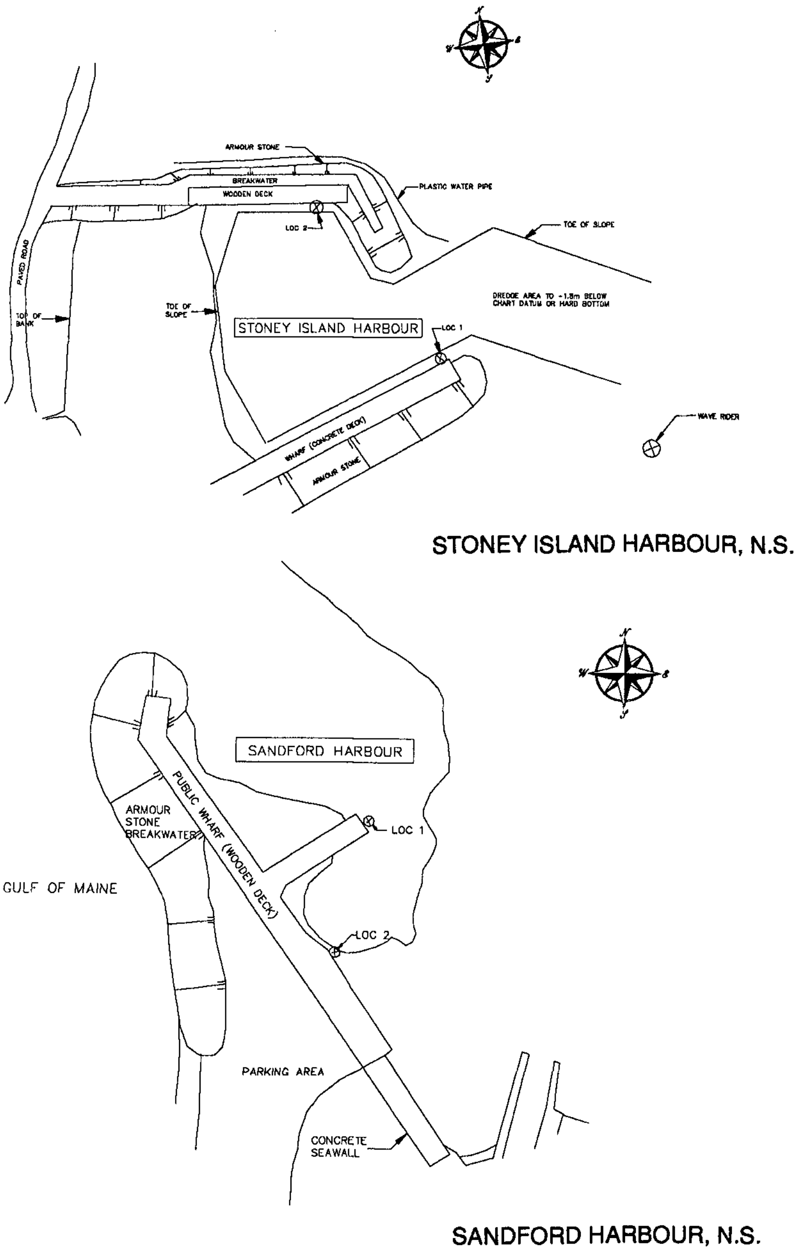

FIGURE 1 Location of selected harbours, Nova Scotia, Canada

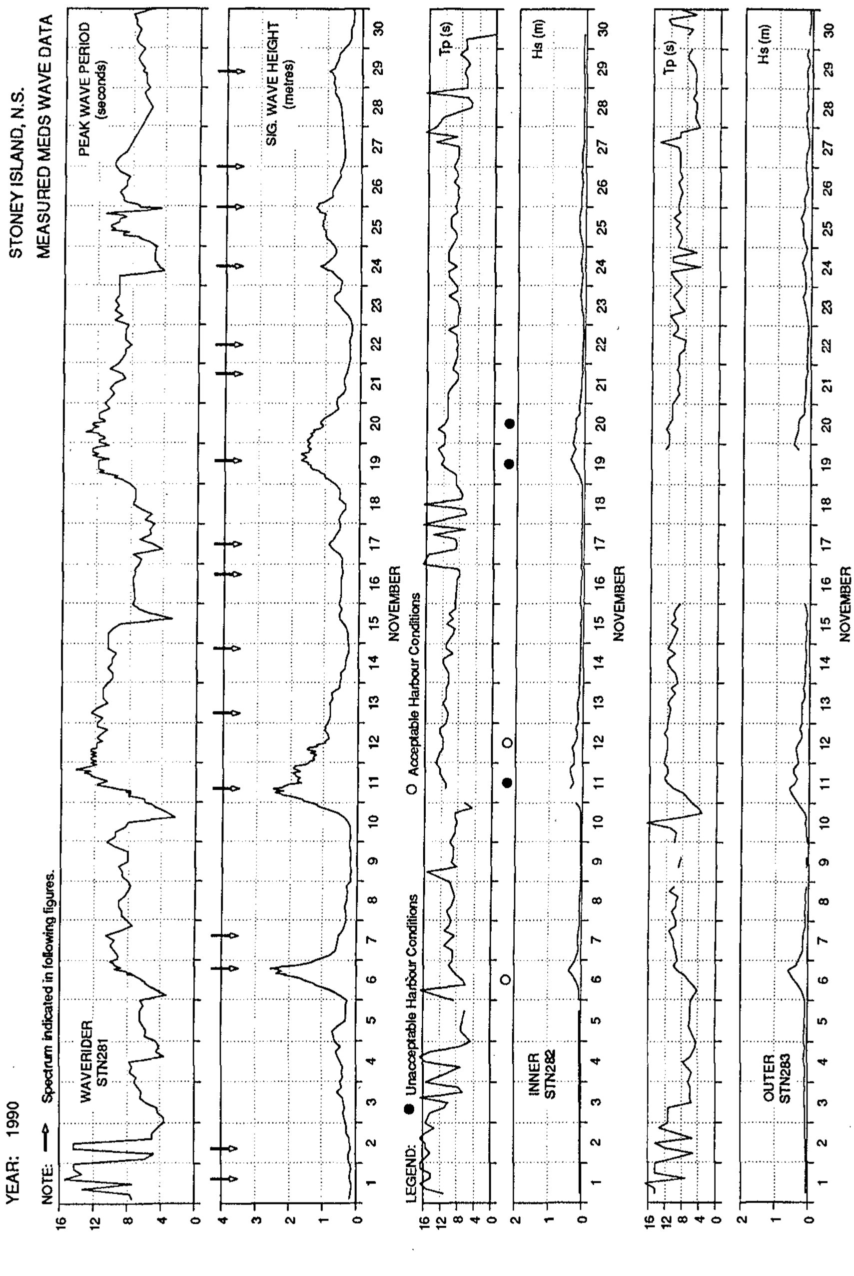

FIGURE 2 Time series plot of wave data for Stoney Island Harbour, November 1990

To establish the directional relationship between the wave conditions inside the harbours and those at the wave riders, the wave heights at inner and outer wave gauges were plotted against those measured at the wave riders for both sites. The fitted equations obtained using linear regression were shown in the plots of Figure 3, for Stoney Island harbour. For this, hindcasted wave directions were used when in concurrence with the wave directions observed by the harbour masters. Otherwise, the observed wave directions were used. Further, a 20 year hindcast representative for the two wave rider locations was performed using the wind data and calibration factors discussed above.

The results of the hindcast were presented in frequency of occurrence tables of the hourly significant wave height and wave period. The 20 year wave climates for both Sandford and Stoney Island, at the harbour wave gauges, were developed using the 20 year wave hindcast and applying the transfer functions given in Figure 3. These transfer functions modify the waves from the wave rider locations to the wave gauge locations. A summary of the wave statistics for all directions for both harbours inner wave gauges was presented in Atria (1991).

Discussion: The threshold value for unacceptable wave agitation (magnitude of wave height which renders the service/offloading area unusable) was determined by linking the harbour master's field observation of harbour agitation conditions to the MEDS measured wave data. The data for Stoney Island is shown in Figure 4. This figure shows a summary plot for all events of unacceptable harbour agitation conditions and the measured wave parameters. Using the Stoney Island inner wave gauge to represent the wave climate at the service/offloading area, the acceptable wave heights range from 0.27 m to 0.43 m and the value of 0.27 m could be considered as the threshold value. Figure 4 also presented a summary plot for the acceptable (but severe) harbour agitation condition. Inspection of the inner wave gauge for Stoney Island indicated that all data for acceptable harbour agitation conditions were under 0.4 m but greater than 0.27 m. This upper bound value could also be considered as the threshold value for unacceptable conditions. These conflicting information may be attributed to measuring errors or other factors such as freezing rain or strong wind conditions, which made the harbour masters feel that the harbour conditions were unacceptable. Closer examination of these two plots indicated that if the data point of 0.27 m wave height is ignored then the unacceptable threshold is about 0.4 m. Considering this, a value of 0.4 m was proposed here as the threshold wave height for unacceptable harbour agitation conditions. Also, this proposed threshold value agrees with the British Standard Code BS6349 that the maximum acceptable significant wave height is 0.4 m for boats up to 30 m. Wave agitation levels greater than this value would induce undesirable vessel motions which could result in vessel damage.

Allowable wave agitation criteria are incomplete without specifications for the frequency of occurrence of the defined threshold value. Determination of the allowable frequency of a specified wave agitation level is basically an economical/policy decision. The scatter diagram for the predicted wave climate for the inner gauge at Stoney Island (Atria, 1991) indicated that the exceedance probability of a wave height greater than 0.4 m is 1.04% and the exceedance probability of a wave height greater than 0.25 m is 4.89%.

According to the SCHD inventory of fishing harbours, both Sandford and Stoney Island harbours are Class B harbours. Under the existing Guidelines of Harbour Accommodation (F&O, 1985), the required allowable maximum wave agitation at the service/offloading area is 0.25 m and its exceedance probability cannot be greater than 0.87%. Based on the existing guideline, Stoney Island harbour would be considered as a problem harbour. However, on average for 15 times per year the fleet at Stoney Island have to abandon the harbour and seek

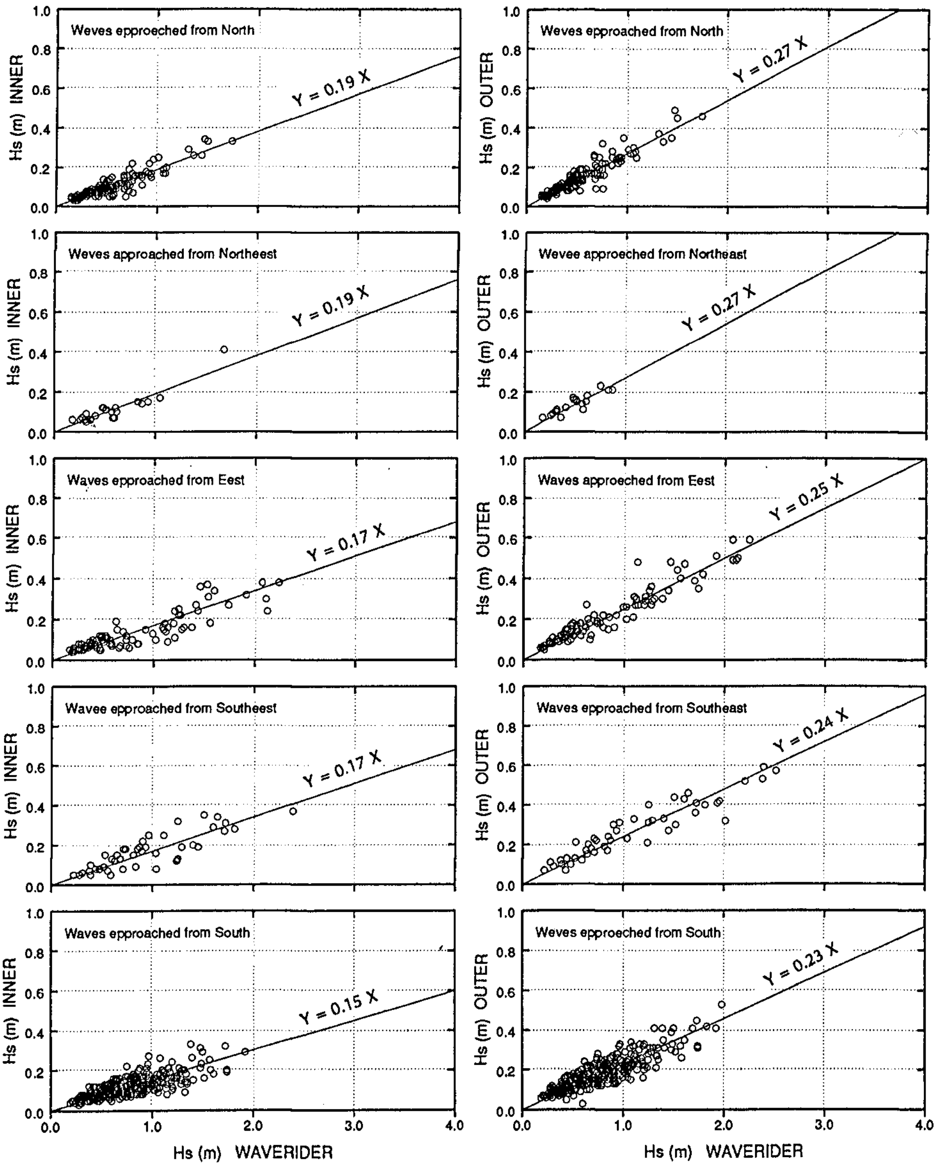

FIGURE 3 Fitted equations for different wave directions, Stoney Island Harbour

refuge at other harbours (J. Ross, SCH, pers. comm., 1991). If this occurrence of refuge seeking is considered acceptable to SCHD, the Stoney Island harbour would be considered as functional and the frequency of wave agitation found in this study could be accepted and applied to other harbours in a generic manner. On the other hand, if SCHD considers this frequency of refuge seeking to be unacceptable, then frequency of 1% may be considered high. When compared to the exceedance probability of 2.5% suggested by the Japanese Ministry of Agriculturc and Fisheries for allowable wave heights of 0.4 m, it does not seems unreasonable that the wave height of 0.4 m cannot be exceeded 1% of the time in a year.

The vessels which operate at Sandford and Stoney Island harbours are known as Cape Islanders which fall into the STACAC (Statistical Coordinating Committee for Atlantic Canada) class 2 (35 to 45 ft) category. The wave measurement programme at Sandford and Stoney Island (and resulting recommended allowable levels of wave agitation) applies to STACAC class 2 vessels. The recommended guidelines proposed here towards allowable levels of wave agitation apply to STACAC class 2 and 3 (45 to 60 ft) fishing vessels in Atlantic Canada.

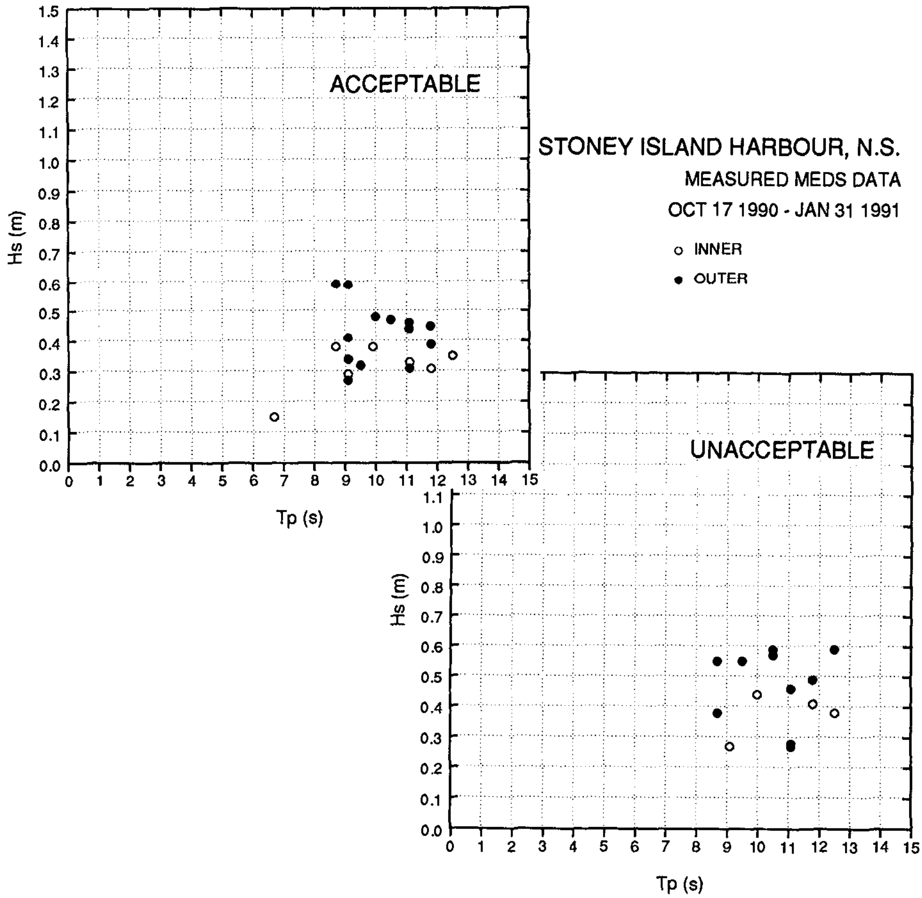

FIGURE 4 Stoney Island Harbour - acceptable and unacceptable harbour conditions

CONCLUSIONS

It is proposed that harbour classification should not be a parameter governing allowable wave agitation criteria, rather vessel classification should be considered as a governing parameter. The rational for this can be explained as follows: a given vessel at berth experiencing beam seas, undergoes the same discomfort from the incoming wave attack as ten of the same vessels moored bow to stern under the same wave conditions. On the other hand, fishing vessels of different class will not respond in (exactly) the same manner under the same wave disturbances and therefore experience different levels of discomfort. Therefore the allowable wave agitation level and its frequency of occurrence should depend on the dominant type of vessel in a harbour, rather than the total vessel meters in that harbour.

The associated frequency of occurrences allow for some down time at the service/offloading wharf at which point in time alternate action will have to be sought by the local fishermen. This alternate action may consist of mooring the vessel in a mooring field, removing the vessel from the harbour by a slip or departing from the harbour altogether and seeking refuge in a nearby harbour (which is the case at Stoney Island harbour). Therefore, the alternate action is a function of the facilities available at each site specific harbour.

Measuring waves in a harbour with an organized harbour monitoring programme proved to be an effective means of determining the threshold point of unacceptable wave agitation as applied to fishing vessels on the Canadian east coast. During the planning and design of commercial fishing harbours, the associated frequency of wave agitation recommended in this document apply to wave events which occur during the fishing season alone.

It was concluded that the results of this study, which were based on wave measurements with peak wave periods in the order of 10 to 13 s, may be safely applied to sites with shorter peak wave periods. Inland waters typically have wave climates which have shorter periods than wave climates in Atlantic Canada. Considering this, it is recommended that the above criteria for wave agitation may be safely applied to inland water commercial fishing harbours.

For planning purposes of Canadian east coast commercial fishing harbours which have predominantly STACAC class 2 or class 3 fishing vessels, it is recommended to use the threshold significant wave height with the associated frequency of occurrence listed in Tables 6 and 7 for the service/offloading wharf and for the mooring basin respectively.

Table 6 Recommended Allowable Wave Agitation Criteria for the Service/Offloading Wharf for STACAC Class 2 and Class 3 Fishing Vessels

Threshold Significant Wave Height	Frequency of Occurrence
0.40 m	1.0 % - 2.5 %

Table 7 Recommended Allowable Wave Agitation Criteria for the Mooring Basin for STACAC Class 2 and Class 3 Fishing Vessels

Threshold Significant Wave Height	Frequency of Occurrence
0.50 m	1.0 % - 2.5 %

Threshold value for unacceptable wave agitation (magnitude of wave height which renders the service/offloading area unusable) for a STACAC class 2 fishing vessel was determined to be 0.4 m. The scatter diagram for the predicted wave climate for the inner gauge at Stoney Island indicated that the exceedance probability of a wave height greater than 0.4 m is 1.04% and the exceedance probability of a wave height greater than 0.25 m is 4.89%. The results of the present study indicated that the frequency of occurrence for wave agitation should be 5 to 6 times greater than the current guidelines values (F&O, 1985).

Allowable wave agitation criteria are incomplete without specifications for the frequency of occurrence of the defined threshold value. Determination of the allowable frequency of a specified wave agitation level is basically an economical/policy decision. A 1% to 2.5% frequency of occurrence of the threshold wave height is recommended.

It is proposed that the results of this study, which apply to STACAC class 2 vessels, may be safely applied to STACAC class 3 vessels. Also, these criteria could possibly be reduced for STACAC class 1 (up to 35 ft) vessels. Atria Engineering Hydraulics Inc. is currently (1992) undertaking a similar field monitoring programme in Newfoundland to determine the threshold values of wave agitation criteria for STACAC class 1 vessels.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation to Small Craft Harbours Branch, Fisheries & Oceans Canada, for financial support of the study.

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