Ship design with a porpoise in mind!

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For readers of this magazine, it should come as no surprise that owners and operators are under growing pressure to ensure that their ships are quiet. The principal contemporary driver for this is the impact of ship-produced Underwater Radiated Noise (URN) on marine mammals. Governmental oversight and regulation of URN are not far off, and all stakeholders — especially the designers of these ships — should evaluate URN in the design process like they would stability or hydrodynamics.

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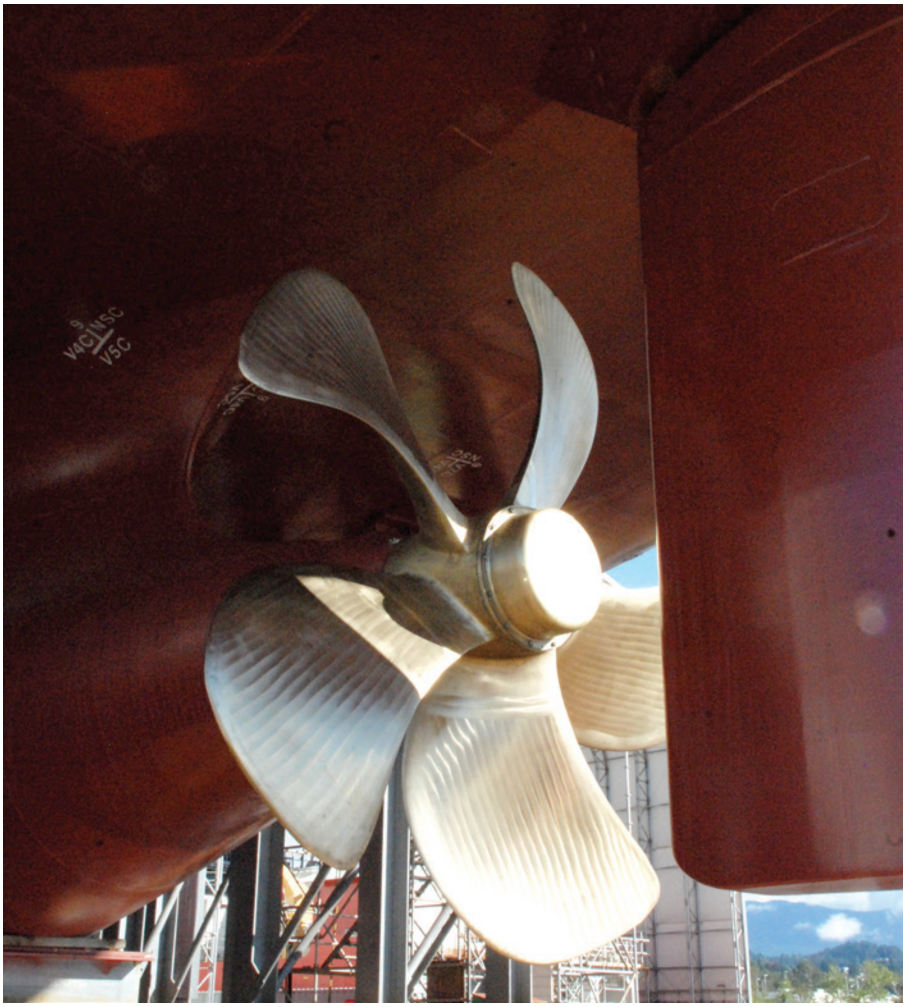
We are blind to the noise

Noise is a transient experience, leaving us with no permanent evidence of what is happening below the ocean surface. While other physical types of detrimental ocean activities are visibly apparent and call for action, the out-of-sight impact of sonic pollution has long been overlooked. We do have evidence, however, via the documentation of marine mammal response to certain noise spectrums plus the measurements of ship noise using transducer arrays. The overlap of the two leaves us with the incontrovertible conclusion that ship-produced URN — which for a containership has been likened to a 190 dB marching band — affects marine mammals in ways that are devastating.

The problem of URN is worldwide. At any given time, over 60,000 ocean-going ships are transiting our oceans. It has been established that noise levels have doubled every decade for the last 60 years. So how do we make ships quieter?



HydroComp's focus on propeller cavitation could help ship owners reduce underwater radiated noise.

Speed limits

The typical regulatory response to issues of noise reduction is to introduce a limit on transit speed. Underwater Radiated Noise is substantially (but not completely) related to propeller cavitation, and any action that reduces cavitation will be beneficial. Reducing speed will indeed lower propeller thrust and cavitation — and noise, if the ship is demonstrating excess propeller-driven noise.

A common speed limit figure is not appropriate, however, as a metric of "acceptable noise" for all ships. As there is a broad range of propulsor and vessel types, some ships will be noisier than others. Companies that invest in noise mitigation and purposeful design will actually find their investment and good will to be meaningless as they are measured against a "worst case" speed limit. If the interest is noise, then let's use practical noise metrics as a way to rank vessel operation in noise-sensitive zones, and not use a one-size-fits-all speed limit.

Shortcomings in noise assessment

Virtually all efforts to reduce noise in ships of commerce happen "after the ship has sailed." Mitigation of excessive URN on an existing vessel, of course, is always expensive and frequently complex. While the cost of mitigation includes the engineering and refit to resolve the noise, it also includes the lost time conducting the company's business. The most effective

Liz McCrary and Donald MacPherson, HydroComp, Inc. are collaborating with others in the maritime industry to advance prediction tools for underwater radiated noise.

and least costly URN prevention is during early-stage design.

Unfortunately, the ship design community currently has very limited options to assess whether URN levels for any particular ship are harmful or dangerous, let alone to propose design revisions to mitigate noise. Noise is a complex physics, and high-order simulation models require a specialist in both hydrodynamic computation and acoustic analysis. Very few design offices have the necessary specialized tools and the experienced staff.

We do have a handful of simplistic models that attempt to connect ship operating metrics to the principal generators of URN — propeller cavitation. There are numerous types of cavitation, with tip vortex cavitation as one of the first and most powerful noise generators. Two of these simplistic models are "Cavitation Inception Speed" (CIS, or the speed at which cavitation starts) and "Turns Per Knot" (TPK, or propeller rotation per ship speed).

Cavitation Inception Speed

It is logical that if one can determine the CIS for a ship, then operation below this speed will be URN-free. Current CIS limits, such as by SNAME (Society of Naval Architects and Marine Engineers) Bulletin 3-37, are regrettably too simplistic to be useful. For example, Bulletin 3-37 states that CIS is at a speed calculated by the following equation where ship length is the only variable:

CIS [kts] = 7 + 0.005 x Ship length [ft]

In other words, CIS is 9.5 knots for all 500-foot ships — regardless of ship type, stern characteristics, or propeller design. Of course, if this type of CIS were to be used for regulation, ship owners who have invested in noise mitigation strategies for the ship and propeller will be considered no differently than any other owner that has not. The use of CIS as a metric for URN is certainly reasonable, but a prediction of CIS that is simplistic and does not consider important ship and propeller design characteristics is not.

Turns Per Knot

This metric is based on the supposition that URN can be principally affected by a change in RPM. There is some merit in this idea, but like CIS, the broad use of TPK for predicting noise reduction is not universally valid. It again does not consider the problem in sufficient detail to provide alternative ways to achieve noise reduction in a manner that might better support the business plan of the ship. The equation to estimate the reduction in Radiated Noise Level (RNL) for a constant speed solely uses RPM and propeller diameter reduction ratios.

While a reduction in RPM or diameter will indeed reduce tip velocities and generally lead to a reduction in tip vortex cavitation, this equation neglects the effect of other hydrodynamic influences. For example, at any given speed, the propeller

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needs to generate a particular thrust. For a reduced RPM, the propeller must have an increased pitch to generate this thrust. If the pitch is increased near the tip — as it likely would be — there is no guarantee that the tip vortex strength will be measurably less than before. Also, if the lower diameter is not compensated with a larger blade area ratio, the significant blade cavitation will rise. An increased blade area will also reduce propeller efficiency, leading to a modest rise in power, fuel consumption and emissions.

In short, the simplistic TPK model omits hydrodynamically significant details that might allow the naval architect to seek out quieter alternatives that do not compromise the owner's business plan. Our industry needs prediction methods that are functional and comprehensive, yet accessible to engineers and naval architects without the support of specialists.

Better design tools for naval architects

Collaborating with other technical partners such as VARD Marine (BC) and Lengkeek Vessel Engineering (NS), HydroComp, Inc. has embarked on a project to develop and deploy new functional URN prediction tools for naval architects. The objective is a URN prediction capability that finds the "sweet spot" between fidelity and functionality that will:

- allow its use by the ship design experts and not require acoustic specialists;
- include ship and propeller descriptors in sufficient detail to allow for investigation of different options that do not compromise the intended performance of the ship;
- be conducted without the need for expensive computational resources; and
- relate to a broad range of vessel types and operating scenarios.

The team will be building upon many years of experience in propeller performance modelling and development of hydrodynamic and propulsion system simulation tools. The basic framework of the prediction models will be the identification of inception for both blade and tip vortex cavitation, along with relationships between cavitation strength and noise levels. It will also include non-cavitating pressure pulse assessment, which is a notable omission from available simplistic methods. The overall objective is to provide naval architects with capabilities to evaluate typical noise-lessening strategies early in design, where actions to mitigate URN are most effective and least costly.

An opportunity to help

To advance this initiative, the team is actively seeking contributors to assist in this meaningful project. A formal "Joint Industry Project" prospectus is available for any company interested in participating as a sponsor or data contributor. All sponsors will be invited to be a partner in the team's activities and outreach.

Owner members of Green Marine may be able to identify their sponsorship as a contributing task to meet "Performance Indicator" criteria of the association's "Underwater Noise" levels. As specifically stated, members are encouraged to: "Support/collaborate on scientific research on underwater noise allowing the estimation of relative ship noise levels."

For additional information about this project, meeting URN compliance criteria for your vessels, or for general URN technical questions, please contact Liz McCrary, URN Project Coordinator, at liz.mccrary@hydrocompinc.com.