Marina DOCK AGE

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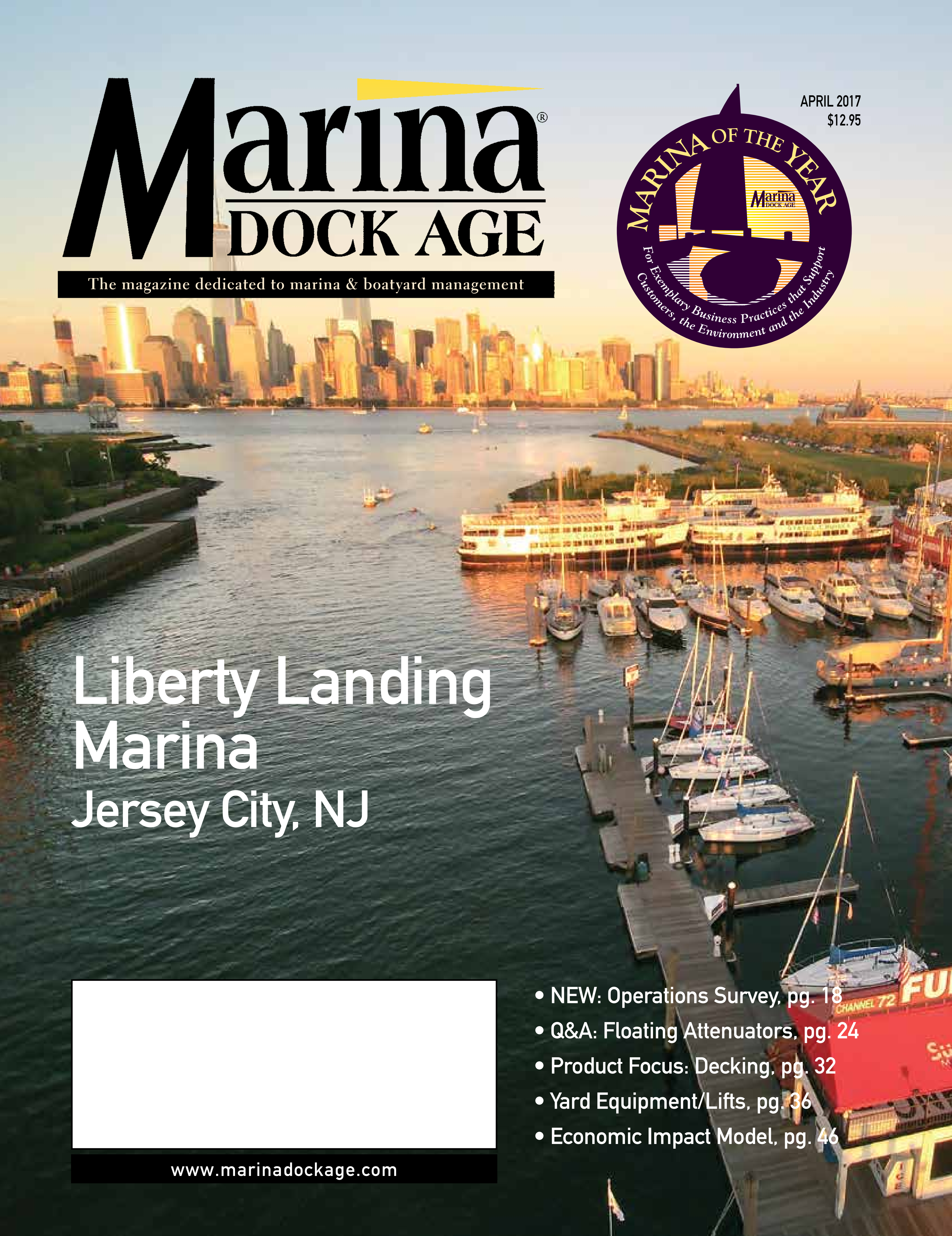

MARINA OF THE YEAR
For Exemplary Business Practices that Support Customers, the Environment and the Industry

Liberty Landing Marina

Jersey City, NJ

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A Conversation about Wave Attenuators

By Robert Wilkes

Floating wave attenuators are a recurring subject in *Marina Dock Age*. Jack Cox wrote about them in "Revisiting Marina Design Standards" in the January/February 2017 issue. This month we present a wide-ranging dialogue between Cox and another experienced engineer, Craig Funston, focused on the question, "What basic knowledge should a marina developer have about wave attenuators?"

Let's meet our engineers for this discussion. Jack Cox is a principal of SmithGroup JJR. Cox spoke to us from his office in Madison, Wisconsin. Craig Funston is principal of Redpoint Structures in Bellingham, Washington. Both have long résumés with impressive marina design projects, including dozens of wave attenuators, and both are respected experts in the field.

Marina Dock Age: *Do you see any trends in developers' criteria for tranquility inside a marina? What do they consider an acceptable wave environment?*

Jack Cox: Owners used to tell me that if their marina was as calm as the competition, it's calm enough. We're not hearing that anymore. Marinas are becoming social neighborhoods and people like to spend time on their boats in the slips. Boaters used to be alarmed when sailboats rocked and their shrouds got tangled. Now they're upset if a guest spills a martini while watching the sunset.

Craig Funston: I agree, but the trend toward quality is true of everything, not just marinas. If we all had to live in the small houses we had in the 1950s we wouldn't be happy. Everything has gotten better, including marinas.

MDA: *How does that present a challenge to engineers?*

CF: All the easily developed sites have been taken, and we're developing sites that are more exposed. Wave attenuator design is more critical to the success of the marina.

MDA: *What are the typical misunderstandings about wave attenuators?*

JC: It's easy to overlook the complexity and believe a wave attenuator is not much different from a floating dock. They look about the same. Wave energy is almost never an orderly, singular wave with a crest parallel to the structure. It's a complex combination of waves of different heights, directions, and periods and includes reflections and refractions from all around the harbor.

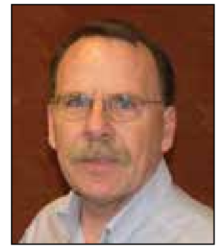
CF: When people look at a wave attenuator and see wave action on one side and smooth water on the other, they think it's performing perfectly. But waves have all these different components, so energy can still be getting through. I tell people wave attenuators are wave filters. A wave attenuator may filter out the short period waves, but if it's not designed properly the long period waves may go through. It's like your neighbor playing loud rock music. You can't hear the high frequencies, but the low frequencies go right through the walls.

JC: Craig is right. It is easy to see rough chop on the water surface but much harder to detect a wave of much longer length. Nevertheless, it's that longer wave as it passes the attenuator, often unabated, that causes the problem inside the marina.

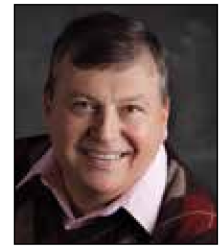
MDA: *When people think about wave attenuators, should they be thinking about mass?*

JC: Wave energy has to be blocked, reflected or somehow eaten up or it will pass through the wave attenuator. Mass is one factor as well as breadth and depth. Another factor is the structure's ability to appear as a rigid, single unit. Motion in the structure transmits wave energy into the marina.

CF: Public marinas have large budgets and are risk averse, so they often go for mass. Some developers want as much mass as they can get for the least dollars. Mass is important but not the whole story.



Craig Funston, principal of Redpoint Structures.



Jack Cox, principal of SmithGroup JJR.

MDA: *What are the other factors?*

JC: The typical floating wave attenuator has skirts. If you think of the structure as a large box, skirts provide most of the benefit without having to build all the structure in between. Also, it matters where the mass is located. The lower the mass, the more stable the structure.

CF: Ideally, you would build one long solid structure, but that's not practical so we have to break it up into modules. And as we said before, waves are almost never simple. They're jumbled and chaotic. So in fact one part of the wave attenuator may be experiencing a crest while the other experiences a trough, and everything in between. Sometimes the forces add together and sometimes they subtract. If you make the attenuator structurally continuous and semi-rigid, you have the opportunity to reduce the overall motion by letting opposing forces work against each other.

JC: That's right. A single monolithic structure does offer the best performance because it acts most like a fixed breakwater. The challenge is achieving this structurally so that it can survive very large waves. A wave attenuator that is constructed of modules hinged together will be more likely to move with the wave and transmit energy into the marina. That's especially true when the period of the structure begins to match the period of the wave. Also, if the anchoring system is flexible, it may also allow movement and energy will get through.

CF: There are other considerations, such as the wear on the hinges, high loads at the corners of the modules and the potential chaffing of utilities in the utility runs. With hinged modules there is likely to be more maintenance over time.

MDA: *If we have to build modules, how do we make the structure more rigid?*

CF: One solid structure is not practical to build. We have to build modules so they can be transported. In order to maintain quality, you have to manufacture in a plant with controlled temperature and humidity. The classic timber waler-connected system works well for connecting the modules. Structural timbers are lapped and layered. When used for wave attenuators, they add more layers and they are rigid enough to greatly reduce hinging motion.

JC: From an engineering standpoint, the best solution is match-cast, post-tensioned structures. Bellingham Marine is a marina builder who is building wave attenuators using this technology and has been doing so for decades.

MDA: *What does that mean?*

CF: Let's take it one part at a time, starting with match casting. That means the floats are cast to fit together and act as one. They cast a float then use the end of that float as a wall of the form when they cast the adjacent float. This way the modules lock together perfectly. Post tensioning means the entire structure is held together under tension by steel cables or high-strength bars running through the length structure high and low. The technique is used all over the world in post-tensioned segmental bridge construction. The result is a solid, one-piece structure.

MDA: *Why tension?*

CF: When the steel cables or bars inside are in tension, the concrete is in compression. Concrete is strong in compression, not as strong in tension. Post-tensioning takes greatest advantage of the inherent strengths of the materials.

MDA: *You mean like the concrete beams in the ceiling of a parking garage?*

CF: Exactly. They're in compression. That's what makes them so strong.

MDA: *Let's talk about anchoring.*

JC: Anchored attenuators usually let more energy through than pile-restrained attenuators. Pile-restrained attenuators perform best because the pontoon is free to move in only one direction—heave. For deep water applications, a properly designed chain and cable system will usually perform well. An elastic rode product such as Seaflex is also a good option. Although it stretches it remains in tension, reacts slowly and doesn't allow the attenuator to move much.

MDA: *Do you do tank testing?*

CF: Yes. The best tank tests simulate the entire harbor so that all reflecting and refracting waves are included. There are developers that think they can put a short section of wave attenuator in front of the marina, and there will be a rectangular shadow of calm water behind it. In fact, the wave energy may be curling around the ends so that the

Most of the naturally protected waterfront locations are taken, so new developments often need to create protection like this wave attenuator at St. George Motor Boat Club in Australia.

shadow is really a triangle.

JC: The lateral length of an attenuator needs to be several times the length of the desired shadow area in order to be effective. If you are trying to shelter a 50-foot yacht, it is likely the length of the breakwater will need to be 150 to 200 feet or so, not just 50 feet.

MDA: *What other advice do you have?*

CF: There are some "gotchas" that developers may overlook, like waves reflecting off an adjacent structure. They may have had no idea that would happen. There may be ferry wakes a developer is not taking into account. Ferry wakes are difficult to attenuate because of the way that energy arrives at the attenuator.

JC: That's true. Structures that work great in a wind-wave environment may cause problems in a ferry or large ship environment.

CF: That's another aspect that Jack touched on in his article, and that is the question, "How often does this bad thing happen." Ferry wakes happen every day, several times a day. If the problem is once in ten years, it's probably OK. If it happens every day, no one will stay.

MDA: *Last words?*

CF and JC: Hire a good engineer! ⚓