structure, where the first acoustic field receiver is configured to measure a first plurality of resulting acoustic fields, where the first plurality of resulting acoustic fields emanate from the first plurality of acoustic signals traveling through the first portion of the underwater structure. The system can further include a controller communicably coupled to the first acoustic field receiver. The controller can be configured to receive the first plurality of resulting acoustic fields from the first acoustic field receiver. The controller can also be configured to analyze the first plurality of resulting acoustic fields. The controller can further be configured to detect, based on analyzing a third harmonic of the first plurality of resulting acoustic fields, a first crack in the first portion of the underwater structure.

[0006] In another aspect, the disclosure can generally relate to a method for detecting cracks in an underwater structure. The method can include receiving, from an acoustic field receiver, a first plurality of resulting acoustic fields, where the first plurality of resulting acoustic fields emanate from a first plurality of acoustic signals traveling through a first portion of the underwater structure, wherein the acoustic field receiver is disposed proximate to, but without physically contacting, the first portion of the underwater structure. The method can also include analyzing the first plurality of resulting acoustic fields. The method can further include detecting, based on analyzing a third harmonic of the first plurality of resulting acoustic fields, a crack in the first portion of the underwater structure.

[0007] In yet another aspect, the disclosure can generally relate to a method for detecting cracks in a structure. The method can include receiving, from an acoustic field receiver, a first plurality of resulting acoustic fields, where the first plurality of resulting acoustic fields emanate from a first plurality of acoustic signals traveling through a first portion of the structure, wherein the acoustic field receiver is disposed proximate to, but without physically contacting, the first portion of the structure. The method can also include analyzing the first plurality of resulting acoustic fields. The method can further include detecting, based on analyzing a third harmonic of the first plurality of resulting acoustic fields and a third harmonic of the second plurality of resulting acoustic fields, a crack in the first portion of the structure.

[0008] These and other aspects, objects, features, and embodiments will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The drawings illustrate only example embodiments of detecting surface cracks using acoustic signals and are therefore not to be considered limiting of its scope, as detecting surface cracks using acoustic signals may admit to other equally effective embodiments. The

CLAIMS

What is claimed is:

1. A system for detecting cracks in an underwater structure, the system comprising:

a first acoustic signal transmitter configured to be disposed proximate to, but without physically contacting, a first portion of the underwater structure, wherein the first acoustic signal transmitter is configured to emit a first plurality of acoustic signals at a first frequency toward the first portion of the underwater structure;

a first acoustic field receiver configured to be disposed proximate to, but without physically contacting, the first portion of the underwater structure, wherein the first acoustic field receiver is configured to measure a first plurality of resulting acoustic fields, wherein the first plurality of resulting acoustic fields emanate from the first plurality of acoustic signals traveling through the first portion of the underwater structure; and

a controller communicably coupled to the first acoustic field receiver, wherein the controller is configured to:

receive the first plurality of resulting acoustic fields from the first acoustic field receiver;

analyze the first plurality of resulting acoustic fields; and

detect, based on analyzing a third harmonic of the first plurality of resulting acoustic fields, a first crack in the first portion of the underwater structure.

2. The system of Claim 1, further comprising:

an underwater vehicle that is configured to navigate underwater, wherein the first acoustic signal transmitter and the first acoustic field receiver are mounted on the underwater vehicle.

3. The system of Claim 2, further comprising:

a network manager communicably coupled to the controller and the underwater vessel, wherein the network manager controls the underwater vehicle to position the first acoustic signal transmitter and the first acoustic field receiver proximate to, but without physically contacting, the first portion of the underwater structure, and wherein the network manager receives detection of the first crack in the first portion of the underwater structure from the controller.

4. The system of Claim 2, wherein the controller is further communicably coupled to the first acoustic signal transmitter, wherein the controller sets the first frequency of the first plurality of acoustic signals.

5. The system of Claim 2, wherein the controller is further communicably coupled to the first acoustic signal transmitter, wherein the controller sets an amplitude of the first plurality of acoustic signals.

6. The system of Claim 1, wherein the first acoustic signal transmitter and the first acoustic field receiver are configured to be moved after the first acoustic signal transmitter emits a second plurality of acoustic signals to a different location proximate to, but without physically touching, the first portion of the underwater structure, wherein the first acoustic signal transmitter is configured to emit a second plurality of acoustic signals, wherein the first acoustic field receiver is configured to receive a second plurality of resulting acoustic fields, wherein the second plurality of resulting acoustic fields emanate from the second plurality of acoustic signals traveling through the first portion of the underwater structure, and wherein the controller is further configured to:

receive the second plurality of resulting acoustic fields from the first acoustic field receiver;

analyze the second plurality of resulting acoustic fields; and

confirm, based on analyzing a third harmonic of the second plurality of resulting acoustic fields, the first crack in the first portion of the underwater structure.

7. The system of Claim 1, wherein the first acoustic signal transmitter and the first acoustic field receiver are configured to be moved after the first acoustic signal transmitter emits a second plurality of acoustic signals to a different location proximate to, but without physically touching, a second portion of the underwater structure, wherein the first acoustic signal transmitter is configured to emit a second plurality of acoustic signals, wherein the first acoustic field receiver is configured to receive a second plurality of resulting acoustic fields, wherein the second plurality of resulting acoustic fields emanate from the second plurality of acoustic signals

traveling through the second portion of the underwater structure, and wherein the controller is further configured to:

receive the second plurality of resulting acoustic fields from the first acoustic field receiver;

analyze the second plurality of resulting acoustic fields; and

detect, based on analyzing a third harmonic of the second plurality of resulting acoustic fields, a second crack in the second portion of the underwater structure.

8. The system of Claim 1, further comprising:

a second acoustic signal transmitter configured to be disposed proximate to, but without physically contacting, a second portion of the underwater structure, wherein the second acoustic signal transmitter is configured to emit a second plurality of acoustic signals at a second frequency toward the second portion of the underwater structure; and

a second acoustic field receiver configured to be disposed proximate to, but without physically contacting, the second portion of the underwater structure, wherein the second acoustic field receiver is configured to receive a second plurality of resulting acoustic fields, wherein the second plurality of resulting acoustic fields emanate from the second plurality of acoustic signals traveling through the second portion of the underwater structure,

wherein the controller is further communicably coupled to the second acoustic field receiver, wherein the controller is further configured to:

receive the second plurality of resulting acoustic fields from the second acoustic field receiver;

analyze the second plurality of resulting acoustic fields; and

detect, based on analyzing a third harmonic of the second plurality of resulting acoustic fields, a second crack in the second portion of the underwater structure.

9. The system of Claim 1, wherein the first acoustic signal transmitter and the first acoustic field receiver are located within two signal lengths of the first plurality of acoustic signals from the first portion of the underwater structure.

10. The system of Claim 1, wherein the first frequency is at least 50 kHz and no greater than 200 kHz.

11. A method for detecting cracks in an underwater structure, the method comprising:

receiving, from an acoustic field receiver, a first plurality of resulting acoustic fields, wherein the first plurality of resulting acoustic fields emanate from a first plurality of acoustic signals traveling through a first portion of the underwater structure, wherein the acoustic field receiver is disposed proximate to, but without physically contacting, the first portion of the underwater structure;

analyzing the first plurality of resulting acoustic fields; and

detecting, based on analyzing a third harmonic of the first plurality of resulting acoustic fields, a crack in the first portion of the underwater structure.

12. The method of Claim 11, further comprising:

instructing an acoustic signal transmitter to emit the first plurality of acoustic signals toward the first portion of the underwater structure, wherein the acoustic signal transmitter is disposed proximate to, but without physically contacting, the first portion of the underwater structure.

13. The system of Claim 11, further comprising:

setting, on the acoustic signal transmitter, at least one of a group consisting of a frequency and an amplitude at which the first plurality of acoustic signals is emitted.

14. The method of Claim 11, further comprising:

controlling an underwater vehicle to position the underwater vehicle proximate to, but without physically contacting, the first portion of the underwater structure, wherein the acoustic signal transmitter and the acoustic field receiver are disposed on the underwater vehicle.

15. The method of Claim 11, further comprising:

receiving, from the acoustic field receiver, a second plurality of resulting acoustic fields, wherein the second plurality of resulting acoustic fields emanate from a second plurality of acoustic signals traveling through the first portion of the underwater structure, wherein the acoustic field receiver is located in a different position relative to when the first plurality of resulting acoustic fields is received;

analyzing the second plurality of resulting acoustic fields; and

further defining, based on analyzing a third harmonic of the second plurality of resulting acoustic fields, the crack in the first portion of the underwater structure.

16. The method of Claim 11, further comprising:
sending a notification about the crack in the first portion of the underwater structure.

17. A method for detecting cracks in a structure, the method comprising:

receiving, from an acoustic field receiver, a first plurality of resulting acoustic fields, wherein the first plurality of resulting acoustic fields emanate from a first plurality of acoustic signals traveling through a first portion of the structure, wherein the acoustic field receiver is disposed proximate to, but without physically contacting, the first portion of the structure;

analyzing the first plurality of resulting acoustic fields; and

detecting, based on analyzing a third harmonic of the first plurality of resulting acoustic fields and a third harmonic of the second plurality of resulting acoustic fields, a crack in the first portion of the structure.

18. The method of Claim 17, wherein the acoustic field receiver and the first portion of the structure are located out of water.