environments to ecological health. Spill-response strategies typically focus on rapid containment of a spill accompanied by attempts to prevent its spreading over large surface areas of ocean waters and from washing ashore. Spill-response strategies also include separation and removal of spilled oil from water. However, these efforts are often overwhelmed by the sheer magnitude of the spills.

Consequently, hydrocarbon loading of nearshore and marine harbour waters typically accumulates and increases over extended periods of time resulting in long-term significantly negative effects on marine life and ecology. It is apparent that current strategies for responding to and ameliorating small and medium-size oil spills, and for remediating hydrocarbon-polluted harbours and terminals, are simply inadequate.

SUMMARY

The ~~embodiment~~example**s** of the present disclosure generally relate to biological response compositions, systems, and methods configured for deployment into marine oil spills for rapid degradation and dispersion of the spills. The biological response compositions disclosed herein may be prepared for and are suitable for deployment into and for rapid dispersion of marine oil spills that comprise primarily light crude oil or alternatively, heavy crude oil, or alternatively, heavy fuel oils, and mixtures thereof. The biological response compositions, systems, and methods are particularly suitable for deployment into small and medium-size spills.

According to some example ~~embodiment~~example**s**, the biological response compositions disclosed herein may comprise combinations of selected dynamic microbiome-based components and carriers selected therefor. The biological response compositions may be capable of self-propulsion into and dispersion within an oil spill. According to some ~~aspect~~example**s**, the selected microbiome components may be enriched by methods disclosed herein, prior to combining with selected carriers therefor. The microbiome components disclosure herein comprise complex naturally occurring mixtures of biological species collected from selected marine waters and selected for their ability to consume straight-

chain and/or branched and/or aromatic hydrocarbons as energy and/or nutrient sources. According to some ~~aspect~~examples, the selected microbiome components may be enriched and stored at or below -70 °C or maintained for extended periods of time by continued culturing in fluid media supplemented with supplies of selected straight-chain and/or branched and/or aromatic hydrocarbons.

Also disclosed herein are example methods for the preparation and maintenance of the selected microbiome components. Large volumes of the biological response compositions disclosed herein may be rapidly prepared after the occurrence of a marine spill, for deployment thereinto as quickly as possible.

Some ~~embodiment~~examples of the present disclosure relate to systems and methods for deploying the biological response compositions disclosed herein, into an oil spill. The systems may include, among other things, containers for transporting the biological response compositions to ocean oil spill locations wherein the biological activities of enriched hydrocarbon-degrading microbiomes in the compositions increase and proliferate during transport. The systems may include equipment and mechanisms for targeted discharge of the biological response compositions into and within a marine oil spill. According to some ~~aspect~~examples, the targeted discharges may be pressurized or alternatively, unpressurized. According to some ~~aspect~~examples, the target discharges may use the same types of pressurizing equipment and nozzles that are used for deployment of chemical dispersants.

Other ~~embodiment~~examples of the present disclosure relate to biological remediation compositions, methods, and compositions configured for deployment into long-term heavily polluted nearshore marine environments such as harbours, ports, and the like, whereon marine vessels are moored for periods of time prior to or after docking for discharge or loading of passengers or cargo. Such long-term heavily polluted nearshore marine environments are known to comprise very high levels of hydrocarbons in their water columns and sediments.

According to some ~~example embodiment~~examples, the biological response compositions disclosed herein may comprise combinations of dynamic microbiome-based components that may be isolated from water columns and/or sediment of highly polluted nearshore marine sites, then enriched and maintained in fluid media supplemented with straight-chain and/or branched and/or aromatic hydrocarbons. The enriched microbiome-based components may be combined with selected carriers for deployment on a regular basis, into a water column of a long-term highly polluted nearshore marine site.

In one aspect, the present disclosure refers to a composition for deployment into marine oil spills, the composition comprising: a plurality of enriched hydrocarbon-degrading microbiome aggregates; a carrier for culturing thereon said plurality of enriched hydrocarbon-degrading microbiome aggregates; and a fluid medium wherein the selected carrier and the plurality of enriched hydrocarbon-degrading microbiome aggregates are suspended; whereby the composition is a dynamic microbiome composition wherein numbers of a plurality of microbial species are increasing and/or decreasing.

In another aspect, the present disclosure refers to a method for producing a composition for deployment into marine oil spills, comprising: collecting a seawater sample from a selected marine water column; culturing the seawater sample in a first liquid medium supplemented with one or more C_{5-40} hydrocarbons selected from crude oils, marine fuels, bunker fuels, diesel fuels, kerosenes, xylenes, benzenes, toluenes, and naphthalene, to thereby select and enrich a hydrocarbon-degrading microbiome therein; mixing the selected hydrocarbon-degrading microbiome in the first liquid medium for at least 7 days at a RPM (revolutions per minute) selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of enriched hydrocarbon-degrading microbiome aggregates comprises microbiome-produced biofilms extending therethrough and thereabout; transferring a portion of the plurality of enriched hydrocarbon-degrading microbiome aggregates into a second liquid medium containing therein a selected carrier; and culturing the transferred portion of enriched hydrocarbon-degrading microbiome aggregates by mixing at a RPM selected from a range of about 0.5 RPM to about 30 RPM for at least 24h, to thereby form the composition.

In another aspect, the present disclosure refers to a method for producing hydrocarbon-enriched microbiome aggregate components for use in formulating a dynamic microbiome-based compositions for deployment into marine oil spills, comprising: collecting a seawater sample from a selected marine water column;

culturing a first portion of the seawater sample in a first liquid medium supplemented with a first selected C_{5-40} hydrocarbon from one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene, to thereby select and enrich a first hydrocarbon-degrading microbiome therein, said first enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.; mixing the first enriched hydrocarbon-degrading microbiome in the first liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of first enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of first enriched hydrocarbon-degrading microbiome aggregates comprises first microbiome-produced biofilms extending therethrough and thereabout; and maintaining the plurality of first enriched hydrocarbon-degrading microbiome aggregates in a viable condition by repeated transfers of the plurality of first enriched hydrocarbon-degrading microbiome aggregates every 7 days into a fresh first selected liquid medium for a continued gentle mixing a RPM selected from a range of about 0.5 RPM to about 30 RPM.

In another aspect, the present disclosure refers to a method of producing a composition for deployment into a marine oil spill, comprising: combining a plurality of the first enriched hydrocarbon-degrading microbiome aggregates produced according to the method as disclosed herein with one or more of a plurality of the second enriched hydrocarbon-degrading microbiome aggregates produced according to the method as disclosed herein, a plurality of the third enriched hydrocarbon-degrading microbiome aggregates produced according to the method as disclosed herein, and a plurality of the fourth enriched hydrocarbon-degrading microbiome aggregates produced according to the method as disclosed herein, transferring the combined pluralities of enriched hydrocarbon-degrading microbiome aggregates into a liquid medium comprising: a carbon-starved minimal medium; a carrier selected from crustacean carcasses, crustacean eggs, crustacean larvae, crustacean juveniles, crustacean fecal matter, crustacean shells, particulate exoskeletons of marine molluscs, particulate shells of marine molluscs, particulate microalgae, particulate macroalgae, clays, zeolites, copepod carcasses, copepod eggs, copepod larvae, copepod juveniles, copepod fecal matter, krill carcasses, krill eggs, krill larvae, krill juveniles, krill fecal matter, and combinations thereof; a C_{5-40} hydrocarbon selected from one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a

toluene, and naphthalene; mixing the combined pluralities of the enriched hydrocarbon-degrading microbiome aggregates, at a temperature selected from one of about 1 °C to about 10 °C, about 10 °C to about 20 °C, and about 15 °C to about 25 °C, in a RPM selected from a range of about 0.5 RPM to about 30 RPM for at least 24 h to thereby produce the tailored dynamic microbiome-based composition.

In another aspect, the present disclosure refers to use of the dynamic microbiome-based composition as disclosed herein to rapidly degrade and ameliorate a marine oil spill.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the present disclosure will become more apparent in the following detailed description in which reference is made to the appended drawings. The appended drawings illustrate one or more embodiments of the present disclosure by way of example only and are not to be construed as limiting the scope of the present disclosure.

FIG. 1 is a chart showing microbial growth measured as changes in optical density (OD) at 600nm, in fuel oil-amended seawater receiving enriched oil-degrading microbiomes combined with a copepod carcasses carrier;

FIG. 2 is a chart showing microbial growth, measured as changes in OD, in fuel oil-amended seawater receiving enriched oil-degrading microbiomes combined with a copepod eggs carrier;

FIG. 3 is chart showing microbial growth, measured as changes in OD, in fuel oil-amended seawater receiving enriched oil-degrading microbiomes combined with a microalgae carrier;

FIG. 4 shows charts illustrating the effects of an “active biological countermeasures” (ABCM) treatment and an enriched microbiome on the degradation of *o*-xylene (FIG. 4A), a mixture of *m*-xylene and *p*-xylene (FIG. 4B), and ethylbenzene (FIG. 4C) in seawater samples, while FIG. 4D is a table showing the reductions in these hydrocarbons compared to natural degradation processes;

Claims:

~~1. A composition for deployment into marine oil spills, the composition comprising:~~

~~a plurality of enriched hydrocarbon-degrading microbiome aggregates; and~~

~~a fluid medium wherein the plurality of enriched hydrocarbon-degrading microbiome aggregates is suspended.~~

~~2. A composition for deployment into marine oil spills, the composition comprising:~~

~~a plurality of enriched hydrocarbon-degrading microbiome aggregates;~~

~~a carrier for culturing thereon said plurality of enriched hydrocarbon-degrading microbiome aggregates; and~~

~~a fluid medium wherein the selected carrier and the plurality of enriched hydrocarbon-degrading microbiome aggregates are suspended.~~

~~3~~1. A composition for deployment into marine oil spills, the composition comprising:

a plurality of enriched hydrocarbon-degrading microbiome aggregates;

a carrier for culturing thereon said plurality of enriched hydrocarbon-degrading microbiome aggregates; and

a fluid medium wherein the selected carrier and the plurality of enriched hydrocarbon-degrading microbiome aggregates are suspended;

whereby the composition is a dynamic microbiome composition wherein numbers of a plurality of microbial species are increasing and/or decreasing.

42. A composition according to ~~any one of claims~~claim 1 ~~to 3~~, additionally comprising one or more selected C_{5-40} hydrocarbons.

53. A composition according to ~~any one of claims~~ claim 1 or 2 ~~to 4~~, additionally comprising one or more of a surfactant, an emulsifier, an enzyme, a dispersant, and combinations thereof.

64. A composition according to any one of claims 1 to 53, wherein the plurality of enriched hydrocarbon-degrading microbiome aggregates is produced by steps comprising:

collecting a seawater sample from a selected marine water column;

culturing the seawater sample in a liquid medium supplemented one or more selected C_{5-40} hydrocarbons selected from one or more of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, naphthalene, and combinations thereof, to thereby select and enrich a hydrocarbon-degrading microbiome, said enriched hydrocarbon-degrading microbiome aggregates comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.; and

mixing the selected hydrocarbon-degrading microbiome in the supplemented liquid medium for at least 7 days at a RPM (revolutions per minute) selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of enriched

hydrocarbon-degrading microbiome aggregates comprises microbiome-produced biofilms extending therethrough and thereabout.

~~7~~5. A composition according to claim ~~6~~4, wherein the seawater sample is cultured at a temperature selected from one of about 1 °C to about 5 °C and therebetween, about 4 °C to about 10 °C and therebetween, about 8 °C to about 15 °C and therebetween, about 13 °C to about 20 °C and therebetween, and about 18 °C to about 25 °C and therebetween.

~~8~~6. A composition according to claim ~~6 or 7~~4 or 5, wherein the marine water column is selected from a hydrocarbon-polluted marine harbour.

~~9. A composition according to any one of claims 6 to 8, wherein the C_{5-40} hydrocarbon is selected from one or more of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, naphthalene, and combinations thereof.~~

~~10. A composition according to any one of claims 6 to 9, wherein the liquid medium is selected from one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~11. A composition according to any one of claims 6 to 10, wherein the plurality of enriched hydrocarbon-degrading microbiome aggregates comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.~~

~~12. A composition according to any one of claims 1 to 11, wherein the fluid medium is a volume of a marine water.~~

~~13~~7. A composition according to any one of claims ~~2 to 12~~1 to 6, wherein the carrier is selected from crustacean carcasses, crustacean eggs, crustacean larvae, crustacean juveniles, crustacean fecal matter, crustacean shells, particulate exoskeletons of marine molluscs, particulate shells of marine molluscs, particulate microalgae, particulate macroalgae, clays, zeolites, copepod carcasses, copepod eggs, copepod larvae, copepod juveniles, copepod fecal matter, krill carcasses, krill eggs, krill larvae, krill juveniles, krill fecal matter, and combinations thereof.

~~14. A composition according to any one of claims 2 to 13, wherein the carrier comprises copepod carcasses, copepod eggs, copepod larvae, copepod juveniles, copepod fecal matter, and combinations thereof.~~

~~15. A composition according to any one of claims 2 to 14, wherein the carrier comprises krill carcasses, krill eggs, krill larvae, krill juveniles, krill fecal matter, and combinations thereof.~~

~~16. A method for producing a composition for deployment into marine oil spills, comprising:~~

~~collecting a seawater sample from a selected marine water column;~~

~~culturing the seawater sample in a first liquid medium supplemented with one or more C_{5-40} hydrocarbons to thereby select and enrich a hydrocarbon-degrading microbiome therein;~~

~~mixing the selected hydrocarbon-degrading microbiome in the first liquid medium for at least 7 days at a RPM (revolutions per minute) selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of enriched hydrocarbon-~~

~~degrading microbiome aggregates comprises microbiome-produced biofilms extending therethrough and thereabout;~~

~~transferring a portion of the plurality of enriched hydrocarbon-degrading microbiome aggregates into a fresh volume of the first liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby increase the plurality of enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of enriched hydrocarbon-degrading microbiome aggregates comprises microbiome-produced biofilms extending therethrough and thereabout;~~

~~optionally repeating the transferring of the portion of the plurality of enriched hydrocarbon-degrading microbiome aggregates into a fresh volume of the first liquid medium, one or more times; and~~

~~transferring the plurality of enriched hydrocarbon-degrading microbiome aggregates into a fluid medium wherein the plurality of enriched hydrocarbon-degrading microbiome aggregates is suspended.~~

~~17~~8. A method for producing a composition for deployment into marine oil spills, comprising:

collecting a seawater sample from a selected marine water column;

culturing the seawater sample in a first liquid medium supplemented with one or more C_{5-40} hydrocarbons selected from crude oils, marine fuels, bunker fuels, diesel fuels, kerosenes, xylenes, benzenes, toluenes, and naphthalene, to thereby select and enrich a hydrocarbon-degrading microbiome therein;

mixing the selected hydrocarbon-degrading microbiome in the first liquid medium for at least 7 days at a RPM (revolutions per minute) selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of enriched hydrocarbon-

degrading microbiome aggregates comprises microbiome-produced biofilms extending therethrough and thereabout;

transferring a portion of the plurality of enriched hydrocarbon-degrading microbiome aggregates into a second liquid medium containing therein a selected carrier; and

culturing the transferred portion of enriched hydrocarbon-degrading microbiome aggregates by mixing at a RPM selected from a range of about 0.5 RPM to about 30 RPM for at least 24h, to thereby form the composition.

~~18. A method according to claim 16 or 17, wherein the first liquid medium is selected from Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~19. A method according to any one of claims 16 or 18, wherein the one or more C_{5-40} hydrocarbons is/are selected from crude oils, marine fuels, bunker fuels, diesel fuels, kerosenes, xylenes, benzenes, toluenes, and naphthalene.~~

~~20~~9. A method according to ~~any one of claims 16 to 19~~ claim 8, wherein the sea water sample is cultured in the first liquid medium at a temperature from one of a range of about 1 °C to about 10 °C, a range of about 10 °C to about 20 °C, and a range of about 15 °C to about 25 °C.

~~21. A method according to any one of claims 16 to 19, wherein the sea water sample is cultured in the first liquid medium at a temperature from a range of about 10 °C to about 20 °C.~~

~~22. A method according to any one of claims 16 to 19, wherein the sea water sample is cultured in the first liquid medium at a temperature from a range of about 15 °C to about 25 °C.~~

~~23~~10. A method according to ~~any one of claims 16 to 19~~ claim 8 or 9, wherein the second liquid medium is a marine water sample additionally comprising a C_{5-40} hydrocarbon selected from crude oils, marine fuels, bunker fuels, diesel fuels, kerosenes, xylenes, benzenes, toluenes, and naphthalene.

~~24. A method according to any one of claims 16 to 20, wherein the second liquid medium additionally comprises one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~25~~11. A method according to any one of claims ~~16 to 24~~8 to 10, wherein the plurality of enriched hydrocarbon-degrading microbiome aggregates comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.

~~26~~12. A method according to any one of claims ~~16 to 25~~8-11, wherein the carrier is selected from one of crustacean carcasses, crustacean eggs, crustacean larvae, crustacean juveniles, crustacean fecal matter, crustacean shells, particulate exoskeletons of marine molluscs, particulate shells of marine molluscs, particulate microalgae, particulate macroalgae, clays, zeolites, copepod carcasses, copepod eggs, copepod larvae, copepod juveniles, copepod fecal matter, krill carcasses, krill eggs, krill larvae, krill juveniles, krill fecal matter, and combinations thereof.

~~27~~13. A method for producing hydrocarbon-enriched microbiome aggregate components for use in formulating a dynamic microbiome-based compositions for deployment into marine oil spills, comprising:

collecting a seawater sample from a selected marine water column;

culturing a first portion of the seawater sample in a first liquid medium supplemented with a first selected C_{5-40} hydrocarbon from one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene, to thereby select and enrich a first hydrocarbon-degrading microbiome therein, said first enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.;

mixing the first enriched hydrocarbon-degrading microbiome in the first liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of first enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of first enriched hydrocarbon-degrading microbiome aggregates comprises first microbiome-produced biofilms extending therethrough and thereabout; and

maintaining the plurality of first enriched hydrocarbon-degrading microbiome aggregates in a viable condition by repeated transfers of the plurality of first enriched hydrocarbon-degrading microbiome aggregates every 7 days into a fresh first selected liquid medium for a continued gentle mixing a RPM selected from a range of about 0.5 RPM to about 30 RPM.

~~28. A method according to claim 27, wherein the first liquid medium is one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution~~

~~(VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~29. A method according to claim 27, wherein the first selected C_{5-40} hydrocarbon is one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene.~~

~~30. A method according to claim 27, wherein the first enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.~~

~~31~~14. A method according to claim ~~27~~13, additionally comprising:

culturing a second portion of the seawater sample in a second liquid medium supplemented with a second selected C_{5-40} hydrocarbon from one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene for at least 7 days, to thereby select and enrich a second hydrocarbon-degrading microbiome therein, said second enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.;

mixing the second enriched hydrocarbon-degrading microbiome in the second liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of second enriched hydrocarbon-degrading microbiome aggregates

wherein each of the plurality of second enriched hydrocarbon-degrading microbiome aggregates comprises second microbiome-produced biofilms extending therethrough and thereabout; and

maintaining the plurality of second enriched hydrocarbon-degrading microbiome aggregates in a viable condition by repeated transfers of the plurality of second enriched hydrocarbon-degrading microbiome aggregates every 7 days into a fresh second selected liquid medium for a continued gentle mixing a RPM selected from a range of about 0.5 RPM to about 30 RPM.

~~32. A method according to claim 31, wherein the second liquid medium is one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~33. A method according to claim 31, wherein the second selected C_{5-40} hydrocarbon is one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene.~~

~~34. A method according to claim 31, wherein the second enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.~~

~~35~~15. A method according to claim ~~27~~14, additionally comprising:

culturing a third portion of the seawater sample in a third liquid medium supplemented with a third selected C_{5-40} hydrocarbon from one or more of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and a naphthalene at a

temperature selected from a range of about 1 °C to about 25 °C for at least 7 days, to thereby select and enrich a third hydrocarbon-degrading microbiome therein, said third enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.;

mixing the third enriched hydrocarbon-degrading microbiome in the third liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of third enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of third enriched hydrocarbon-degrading microbiome aggregates comprises third microbiome-produced biofilms extending therethrough and thereabout; and

maintaining the plurality of third enriched hydrocarbon-degrading microbiome aggregates in a viable condition by repeated transfers of the plurality of third enriched hydrocarbon-degrading microbiome aggregates every 7 days into a fresh third selected liquid medium for a continued gentle mixing a RPM selected from a range of about 0.5 RPM to about 30 RPM.

~~36. A method according to claim 35, wherein the third liquid medium is one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~37. A method according to claim 35, wherein the third selected C_{5-40} hydrocarbon is one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene.~~

~~38. A method according to claim 35, wherein the third enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.~~

~~39~~16. A method according to claim ~~27~~15, additionally comprising:

culturing a fourth portion of the seawater sample in a fourth liquid medium supplemented with a fourth selected C_{5-40} hydrocarbon selected from crude oils, marine fuels, bunker fuels, diesel fuels, kerosenes, xylenes, benzenes, toluenes, and naphthalene, for at least 7 days~~,~~ to thereby select and enrich a fourth hydrocarbon-degrading microbiome therein;

mixing the fourth enriched hydrocarbon-degrading microbiome in the third liquid medium for at least 7 days at a RPM selected from a range of about 0.5 RPM to about 30 RPM to thereby form the plurality of fourth enriched hydrocarbon-degrading microbiome aggregates wherein each of the plurality of fourth enriched hydrocarbon-degrading microbiome aggregates comprises fourth microbiome-produced biofilms extending therethrough and thereabout; and

maintaining the plurality of fourth enriched hydrocarbon-degrading microbiome aggregates in a viable condition by repeated transfers of the plurality of fourth enriched hydrocarbon-degrading microbiome aggregates every 7 days into a fresh fourth selected liquid medium for a continued gentle mixing a RPM selected from a range of about 0.5 RPM to about 30 RPM.

~~40. A method according to claim 39, wherein the fourth liquid medium is one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution~~

~~(VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth.~~

~~41. A method according to claim 39, wherein the fourth selected C_{5-40} hydrocarbon is one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene.~~

~~42. A method according to claim 39, wherein the fourth enriched hydrocarbon-degrading microbiome comprises one or more of *Acanthopleuribacter* spp., *Acinetobactor* spp., *Alcanivorax* spp., *Alteromonadaceae* spp., *Cycloclasticus* spp., *Flavobacterium* spp., *Hyphomonas* spp., *Marinobacter* spp., *Porticoccaeae* spp., *Pseudomonas* spp., *Rhodobacteraceae* spp., *Sphingopyxis* spp., *Sphingobium* spp., *Xanthobacter* spp.~~

~~43~~17. A method according to claim ~~39~~16, wherein the fourth enriched hydrocarbon-degrading microbiome is recultured, mixed again, and maintained again, one or more times.

~~44~~18. A method of producing a composition for deployment into a marine oil spill, comprising:

combining a plurality of the first enriched hydrocarbon-degrading microbiome aggregates produced according to the method of claim ~~27~~ 13 with one or more of a plurality of the second enriched hydrocarbon-degrading microbiome aggregates produced according to the method of claim ~~31~~14, a plurality of the third enriched hydrocarbon-degrading microbiome aggregates produced according to the method of claim ~~35~~15, and a plurality of the fourth enriched hydrocarbon-degrading microbiome aggregates produced according to the method of claim ~~39~~16,

transferring the combined pluralities of enriched hydrocarbon-degrading microbiome aggregates into a liquid medium comprising:

a carbon-starved minimal medium;

a carrier selected from crustacean carcasses, crustacean eggs, crustacean larvae, crustacean juveniles, crustacean fecal matter, crustacean shells, particulate exoskeletons of marine molluscs, particulate shells of marine molluscs, particulate microalgae, particulate macroalgae, clays, zeolites, copepod carcasses, copepod eggs, copepod larvae, copepod juveniles, copepod fecal matter, krill carcasses, krill eggs, krill larvae, krill juveniles, krill fecal matter, and combinations thereof;

a C_{5-40} hydrocarbon selected from one of a crude oil, a marine fuel, a bunker fuel, a diesel fuel, kerosene, a xylene, a benzene, a toluene, and naphthalene;

mixing the combined pluralities of the enriched hydrocarbon-degrading microbiome aggregates, at a temperature selected from one of about 1 °C to about 10 °C, about 10 °C to about 20 °C, and about 15 °C to about 25 °C, in a RPM selected from a range of about 0.5 RPM to about 30 RPM for at least 24 h to thereby produce the tailored dynamic microbiome-based composition.

~~45. A method according to claim 44, wherein the liquid medium additionally comprises a selected C_{5-40} hydrocarbon.~~

~~46. A method according to claim 44, wherein the carbon-starved minimal medium is one of Buschnell Haas nutrient broth, Väätänen Nine-Salt Solution (VNSS), marine broth, Luria-Bertani marine broth, 2% NaCl Mueller-Hinton broth, and Zobell marine broth;~~

~~47~~19. A method according to claim ~~44~~18, wherein one or more of a surfactant, an emulsifier, an enzyme, a dispersant, and combinations thereof, is added into the composition.

~~48. A method according to claim 44, additionally comprising the one or more recultured, mixed again, and maintained again fourth enriched hydrocarbon-degrading microbiome.~~

~~49. A method according to claim 44, wherein the mixing is performed at a temperature selected from one of about 1 °C to about 10 °C, about 10 °C to about 20 °C, and about 15 °C to about 25 °C,~~

~~50~~20. Use of the dynamic microbiome-based composition according to any one of claims 1 to ~~15~~7~~,~~ to rapidly degrade and ameliorate a marine oil spill.